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WATER QUALITY INVESTIGATIONS: SOURIS RIVER BASIN, NORTH DAKOTA 1969

Bob Hegg

Environmental Protection Agency
Kansas City, Missouri

February 1971

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WATER QUALITY
INVESTIGATIONS

SOURIS RIVER BASIN

NORTH DAKOTA 1969

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S O U R I S R I V E R B A S I N

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Environmental Protection Agency
Water Quality Office - Region VII
911 Walnut, Kansas City, Mo. 64106

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TABLE OF CONTENTS

Section	Title	Page
	List of Figures	iii
	List of Tables	iv
I	Introduction	1
	A. Statement of Problem	1
	B. Report Objectives	1
	C. Scope	1
	D. Authority	2
	E. Acknowledgements	2
II	Summary of Conclusions and Recommendations	3
	A. Summary of Conclusions	3
	B. Recommendations	6
III	Description of Area	8
	A. Physical Description	8
	B. Climate	8
	C. Streamflow	10
	D. Water Management	12
	E. Population and Economy	12
IV	Sources of Pollution	14
	A. Municipal and Industrial Waste Sources	14
	1. Crosby, North Dakota	14
	2. Columbus, North Dakota	15
	3. Kenmare, North Dakota	15
	4. Minot, North Dakota	15
	5. Velva, North Dakota	16
	6. Towner, North Dakota	16
	7. Minot Air Force Base	16
	8. Lignite Mining Areas	17
	B. Agricultural Sources	17
	1. Animal Wastes	17
	2. Irrigation Return Flows	17
	3. Rural Runoff	17
	C. Wildlife Refuges	18
V	Field Investigations	19
	A. Biological Surveys	19
	1. Biological Sampling Stations	19
	2. Survey Methodology	19
	B. Chemical and Microbiological Survey	24
	1. Sampling Stations	24
	2. Water Quality Parameters Evaluated	24
VI	Water Quality Evaluations	26
	A. Applicable Water Quality Standards	26
	B. Water Quality Conditions	26
	1. Dissolved Oxygen	26
	2. Biochemical Oxygen Demand	31
	3. Inorganic Constituents	34
	4. Nitrogen and Phosphorus	37
	5. Bacterial Concentrations	43
	6. Other Parameters	45

TABLE OF CONTENTS (continued)

Section	Title	Page
VII	Biological Evaluations	46
	A. Biological Indicators of Water Quality	46
	B. Benthos	46
	1. Souris River	47
	2. Des Lacs River Stations	51
	C. Phytoplankton	54
	1. Souris River	54
	2. Des Lacs River	54
	D. Sediments	58
Appendix A	Water Quality Standards	A-1
References	. . . . .	62

LIST OF FIGURES

Figure No.	Title	Page
III-1	Study Area - Souris River Drainage, North Dakota	9
V-1	Biological Stations - Souris River Drainage, North Dakota	22
V-2	Chemical and Bacteriological Stations Souris River Drainage, North Dakota	23
VI-1	Nitrogen and Phosphorus Concentrations	39
VI-2	Average Pounds Per Day of Total Phosphorus and Nitrate-Nitrogen	42

LIST OF TABLES

Table No.	Table	Page
III-1	Precipitation Data for July Sampling Period	10
III-2	Average Daily Streamflow - July 7-16, 1969	11
IV-1	Municipal and Industrial Waste Sources	14
V-1	Sampling Station Locations	20
V-2	Chemical and Bacteriological Analyses Schedule	25
VI-1	Dissolved Oxygen, Temperature, pH and Turbidity Data - July 7-16, 1969	28
VI-2	Water Quality Monitor Data -- River Mile 88.0	29
VI-3	Water Quality Monitor Data -- River Mile 267.4	30
VI-4	Biochemical Oxygen Demand Data	32
VI-5	Average Ionic Concentrations	36
VI-6	Nitrogen and Phosphorus	40
VI-7	Average Nitrogen and Phosphorus	41
VI-8	Bacteriological Data	44
VII-1	Bottom Associated Organisms, Souris River - North Dakota and Canada - June 1969	48
VII-2	Bottom Associated Organisms, Souris River - North Dakota and Canada - October 1969	49
VII-3	Bottom Associated Organisms, Des Lacs River - North Dakota - June 1969	52
VII-4	Bottom Associated Organisms, Des Lacs River - North Dakota - October 1969	53
VII-5	Phytoplankton Data - June 1969	55
VII-6	Phytoplankton Data - October 1969	56
VII-7	Predominant Phytoplankton Genera	57
VII-8	Organic Sediment Index for Typical Bottom Sediments	59
VII-9	Organic Carbon, Nitrogen, and Phosphorus in Sediments	60
VII-10	Souris River Organic Sediment Indices	61

CHAPTER I. INTRODUCTION

A. STATEMENT OF PROBLEM

The Souris River is an international stream which originates in the Province of Saskatchewan, Canada. The river flows southward from Canada into North Dakota and then, after making a large horseshoe bend, flows northward into the Canadian Province of Manitoba. Water uses in the United States affect both the quality and quantity of water released to Canada.

Various water rights and International agreements govern the use of Souris River water in the United States and regulate release of water to Canada. Since the Basin's water supply is not adequate to meet the needs of all potential water uses, conflicts exist over priority of water use. Large variations in annual runoff compound these water use conflicts.

Water quality degradation resulting from natural and man-made causes produces some impairment of water uses. The river system is eutrophic with algal blooms and high nutrient levels frequently occurring. Prior to this survey, only limited water quality data were available for evaluation of the effects of sources of water quality degradation. Waste sources include untreated and inadequately treated municipal and industrial wastes, agricultural wastes, urban runoff, rural runoff, and several large wildlife refuges.

No basinwide water quality management plan exists. Improved treatment facilities have recently been completed for several municipal and industrial sources to alleviate some water quality degradation. However, there is need of a basinwide plan to furnish requirements for future treatment needs for both existing and new waste discharges; and to minimize the water quality impact of future changes in water use such as will result from the operation of the proposed Garrison Diversion Irrigation Project.

B. REPORT OBJECTIVES

The primary objectives of this report are to:

1. Assess the impact of municipal and industrial waste discharges on water quality conditions in the Souris River System.
2. Define water quality conditions in the wildlife refuge areas as technical assistance to the Bureau of Sport Fisheries and Wildlife.
3. Provide background data on inorganic constituents in the river system as a basis for evaluating the water quality effects of the Garrison Diversion Irrigation Project.

C. SCOPE

This report summarizes a study of water quality conditions in the United States portion of the Souris River Basin. Field investigations for the study were conducted during June-October, 1969.

Water quality sampling for chemical and bacteriological parameters was conducted during the period July 7-20, 1969. Municipal and industrial waste sources considered potential sources of significant water quality degradation were also investigated during the surveys.

D. AUTHORITY

The Water Quality Office of the Environmental Protection Agency (formerly the Federal Water Quality Administration, Department of the Interior) is the agency of the Federal Government which has primary responsibility for implementation of a national policy for enhancement of the quality of the nation's water resources through the control of pollution. This policy has been delineated in legislative acts and amendments over the past 15 years which are described as the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.). The Act authorizes the Administrator of the Environmental Protection Agency (EPA) to conduct investigations of water quality conditions, to provide technical assistance to other Federal agencies in matters of pollution control and to develop comprehensive programs for reducing pollution of interstate waters and their tributaries.

This study was undertaken at the request of the Bureau of Sport Fisheries and Wildlife (BSFW) to provide technical assistance in assessing the water quality impact on the Souris River wildlife refuges which they operate. Basic study plans were formulated at a meeting of BSFW and EPA personnel on February 19, 1969.

E. ACKNOWLEDGEMENTS

Field investigations for this study were conducted by personnel from the Water Quality Office, Region VII, Environmental Protection Agency (formerly the Missouri Basin Region, Federal Water Quality Administration) with assistance from BSFW. The valuable assistance given by BSFW personnel Messrs. Rodney King and Ervine Rostad during the field operations was greatly appreciated.

Laboratory support for the study was provided by Region VII, EPA. Assistance in preparation of the final report was provided by the Division of Field Investigations - Denver Center, Water Quality Office, EPA.

In addition, the assistance and/or information provided by numerous City, State and Federal officials is hereby acknowledged.

CHAPTER II. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY OF CONCLUSIONS

A water quality investigation was carried out during the summer and fall of 1969 to provide information on basic water quality conditions in the Souris River Basin and to define sources of water quality degradation. Physical, chemical, bacteriological and biological parameters were evaluated at a number of locations throughout the United States portion of the Basin.

Water quality conditions reflected a river system which was basically eutrophic. Nutrient concentrations, especially phosphorus, were adequate to support intense algal blooms under favorable conditions for algal growth. Intense blooms of blue-green algae have occurred which have produced nuisance conditions, taste and odor problems in water withdrawn for domestic use and livestock deaths. Background levels of degradable organic materials derived from decaying vegetation in shallow impoundments exerted a significant oxygen demand resulting in depressed dissolved oxygen concentrations at some locations. Bottom sediments contained large quantities of nutrients and organic detritus which could serve as reservoirs for recycling of these materials into basin waters.

Water quality was found to be degraded by untreated municipal waste discharges at the North Dakota communities of Kenmare, Velva and Towner and by the industrial waste discharge from Winger Cheese Company at Towner. All of these waste dischargers presently provide secondary treatment.

At the time of the water quality investigations, effluent from the Minot, North Dakota, waste stabilization lagoons was discharged to a dry wash and did not reach the Souris River. This effluent has recently been diverted directly to the Souris River. The impact of this new discharge on water quality has not been measured.

Municipal and industrial waste effluents increased the nutrient load carried by the river system. Removal of nutrients from these effluents would decrease nutrient concentrations in the river system. Present data are inadequate; however, to provide the basis for determining if such high level treatment would result in substantial water quality enhancement in the face of the existing eutrophic nature of the Basin.

Other sources of nutrients, oxygen-demanding materials and other pollutants which degrade water quality can be found in runoff from unused land, agricultural runoff including animal feedlot drainage, irrigation return flows, urban runoff, decaying vegetation in shallow impoundments and large flocks of migrating waterfowl. Three large wildlife refuges operated by the Bureau of Sport Fisheries and Wildlife, the Upper Souris National Wildlife Refuge, the Des Lacs National Wildlife Refuge, and the J. Clark Salyer Wildlife Refuge, contain large areas of shallow impoundments which significantly affect water quality conditions in the river system by creating an environment favorable to the utilization and deposition of nutrients.

Waters of the United States portion of the Souris River Basin are primarily utilized for the maintenance of habitat for waterfowl and other wildlife in the three large wildlife refuges. The Souris River also serves as a source of municipal water supply for the City of Minot, North Dakota, and supply of irrigation water. Recreational uses of the basin waters include fishing, hunting, boating, and swimming with the most intensive recreational use occurring in the large impoundments such as Lake Darling.

The distribution and use of Souris River water is controlled by various water rights and several International agreements. Water supply is inadequate to provide for all desired uses and conflicts exist over priority of water use. Droughts and seasonal fluctuations in the available supply compound these conflicts. Streamflow in the Souris River is regulated by storage in Lake Darling in the Upper Souris National Wildlife Refuge which is primarily controlled for wildlife refuge uses.

Water quality standards applicable to the interstate waters of the Souris River Basin, including the Des Lacs and Souris Rivers, have been established by the North Dakota State Department of Health and approved by the Secretary of the Interior in accordance with the Federal Water Pollution Control Act, as amended. These standards include water quality criteria which provide specific limits on various physical, chemical and bacteriological parameters. Water quality conditions were found to be in violation of one or more water quality criteria at several locations on the Souris and Des Lacs Rivers.

Dissolved oxygen concentrations were in violation of the applicable criterion in Middle Des Lacs Lake near Kenmare, in the Souris River below Towner, and in the J. Clark Salyer Wildlife Refuge. The Kenmare and Towner violations were because of untreated waste discharges which now receive secondary treatment. The third violation was caused by eutrophic conditions in the refuge impoundments.

Violations of total coliform criteria occurred in two reaches of the Souris River. In the vicinity of Minot, total coliform concentrations violated limits set by North Dakota Water Quality Standards. The communities of Towner and Velva waste discharges caused gross violations of total coliform limits in the Lower Souris River. Although violations of total coliform limits occurred, fecal coliform concentrations complied with North Dakota recommended limits for designated water uses at all locations in the Basin except near untreated waste discharges.

Iron and manganese concentrations at several locations were found to be above desirable criteria specified in the Public Health Service Drinking Water Standards. These high concentrations, which appear to originate from uncontrollable natural sources, may contribute to taste and odor problems which occur in the Minot municipal water supply.

Dissolved mineral concentrations, primarily sulphates and total dissolved solids, are approaching upper limits of the desirable criteria specified in the Public Health Service Drinking Water Standards and are approaching threshold limits for impairment of irrigation uses. Future changes in

water use, including importation of water by the proposed Garrison Diversion Irrigation Project, may result in higher dissolved solids concentrations.

The City of Minot discharges lime sludge from its water treatment plant directly to the Souris River. This sludge has completely eliminated bottom dwelling aquatic life in a 3/4 mile reach of the river. This discharge is in violation of water quality standards.

Crosby, North Dakota, discharges untreated municipal wastes to a swampy area which serves as a waste stabilization lagoon. This facility cannot be operated properly and should be upgraded to provide adequate treatment or replaced with a new waste treatment facility.

Municipal wastes from Columbus, North Dakota, receive primary treatment in a covered Imhoff tank. The facility is being properly operated except that accumulated solids are periodically returned to the plant effluent. These solids should be removed to a sanitary landfill or other approved method of disposal utilized.

Oil pollution which causes some surface oil slicks and oil in the bottom sediments was observed in the Minot urban area. Some indiscriminate dumping of oil from service stations and other sources was noted. A program to enforce prohibitions against dumping of oil is needed.

Sanitation facilities for private summer homes in the Mouse River Park area are inadequate. "Privies" placed directly over the water were observed. Local health authorities should take actions to require adequate sanitation facilities.

Other than the plan of implementation contained in the water quality standards, no comprehensive plan exists for the basinwide management of water quality. Such a plan should be developed by the State of North Dakota and implemented to provide for the enhancement of the quality and value of the Basin's water resources. This plan should include consideration of such factors as importation of a supplemental water supply by the proposed Garrison Diversion Irrigation Project, operation of the wildlife refuges to minimize their water quality impact and provide flow regulation for water quality enhancement, and the potential need for reducing the discharge of nutrients from controllable sources.

Available data on water quality conditions in the basin are limited. Because of unusually high precipitation during the first half of 1969, stream flow conditions were above normal during the water quality investigations. Data obtained thus do not reflect water quality conditions during critical low flow periods. Also, significant changes have been made since the survey in the volume and characteristics of municipal and industrial wastes discharged to the system.

Continuing water quality data collection is needed to provide information on long-term changes in water quality conditions and to provide additional data for use in development of a water quality management plan. A water quality sampling network should be established in cooperation with the State Water Pollution Control Agency for this purpose.

B. RECOMMENDATIONS

It is recommended that the following actions be undertaken by joint Federal and State agencies as soon as practicable to abate existing pollution and provide enhancement of water quality in the Souris River system:

1. A waste source survey should be conducted to evaluate the treatment efficiencies achieved by existing municipal and industrial waste treatment facilities and to determine the magnitude and characteristics of treated effluents. Emphasis should be placed on defining the quantities of carbonaceous organic material as well as nitrogen and phosphorus discharged by each source. Evaluation and upgrading of treatment plant operation should be included.
2. An intensive short-term water quality survey should be conducted during the low streamflow, high water temperature period of late summer to evaluate the impact of waste sources on water quality during this critical period and to define basic water quality conditions during low flow periods. Emphasis should be placed on developing a detailed nitrogen and phosphorus balance for the river system.
3. Following completion of the waste source and water quality surveys, the need for removal of nitrogen and/or phosphorus from each waste discharge should be evaluated and appropriate treatment improvements recommended where indicated.
4. The City of Minot should resume discharging the effluent from its waste stabilization lagoons to the dry coulee to eliminate the impact of this effluent on water quality in the Souris River. Consideration should be given to the implementation of regulations by the North Dakota State Department of Health prohibiting waste discharges from waste stabilization lagoons to surface streams in the Souris River Basin.
5. The City of Minot should cease its discharge of lime sludge from the water treatment plant to the Souris River. This is a violation of water quality standards.
6. A program should be undertaken by the State Health Department to eliminate the discharge of oil from controllable sources such as service stations in the Minot urban area.
7. A program should be undertaken to abate the discharge of untreated drainage from animal feedlots to surface streams.
8. The existing waste treatment facility at Crosby, North Dakota, should be upgraded or replaced to achieve secondary treatment.
9. Local health authorities should take action to require adequate sanitation facilities for the Mouse River Park summer home area.
10. The North Dakota water quality standards should be revised to provide additional protection for water uses. Such revisions should include specific limits on dissolved solids and conversion of total coliform bacterial criteria to fecal coliform basis.

11. A water quality sampling network should be established to provide long-term collection of water quality data at regular intervals at key locations to define seasonal and long-term changes in basic water quality conditions.

CHAPTER III. DESCRIPTION OF AREA

A. PHYSICAL DESCRIPTION

The Souris River is an international stream draining portions of the United States and Canada (see Figure III-1). About 15,480 square miles of its total drainage area of 24,800 square miles are located in Canada and the remaining 9,320 square miles are located in North Dakota. The river originates in the Province of Saskatchewan and flows in a southeasterly direction entering the United States about 25 miles west of Sherwood, North Dakota. It continues this course to a point about 20 miles southeast of Minot, North Dakota, where it bends northward entering the Province of Manitoba near Westhope, North Dakota. About 358 miles of the river's total length of 792 miles are located in the United States. In Canada, the Souris River joins the Assiniboine River, a tributary of the Red River.

The Des Lacs River, the major tributary of the Souris River, rises approximately 2 miles north of the International Boundary in Saskatchewan, Canada. From the boundary it flows southeastward in North Dakota for about 110 river miles where it enters the Souris River near Burlington, North Dakota. Other tributaries within the United States are Wintering and Deep Rivers and Willow Creek.

Major topographical features of the Souris River Basin are the Turtle Mountains and the Souris Lake Plain. The Turtle Mountains are a rolling glaciated plateau which rises 400 to 600 feet in elevation above the surrounding plains. The Souris Lake Plain is a lacustrine plain of glacial origin. Nearly flat, the plain slopes only a few feet per mile towards the Souris River. Typical of glaciated drift prairie, many of the plains areas lack continuous drainage. Potholes and intermittent streams are numerous.

Both the Des Lacs and Souris Rivers are impounded for a portion of their length in the United States. Lake Darling, northwest of Minot, is the largest reservoir. Most impoundments are relatively small and shallow and are utilized as wildlife refuges. Free flowing portions of the Souris River in the United States average about 80 feet in width and 12 feet in depth. Average slope of the North Dakota reach is 0.56 feet per mile, which is typical of a drift prairie stream.

B. CLIMATE

The Souris River Basin has a continental climate characterized by extreme variations in temperature, insufficient rainfall for crops in many years, and moderate snowfall. Recorded temperatures range from a low of -54°F. to a high of 114°F. The mean annual temperature is 39°F. and annual precipitation averages 15.5 inches. Snowfall averages 33 inches annually and constitutes about 20 percent of yearly precipitation.

Precipitation during 1969 totalled a near normal 15.7 inches at Kenmare. For the first four months of 1969, precipitation was 44 percent above average, however, because of heavy snowfall during

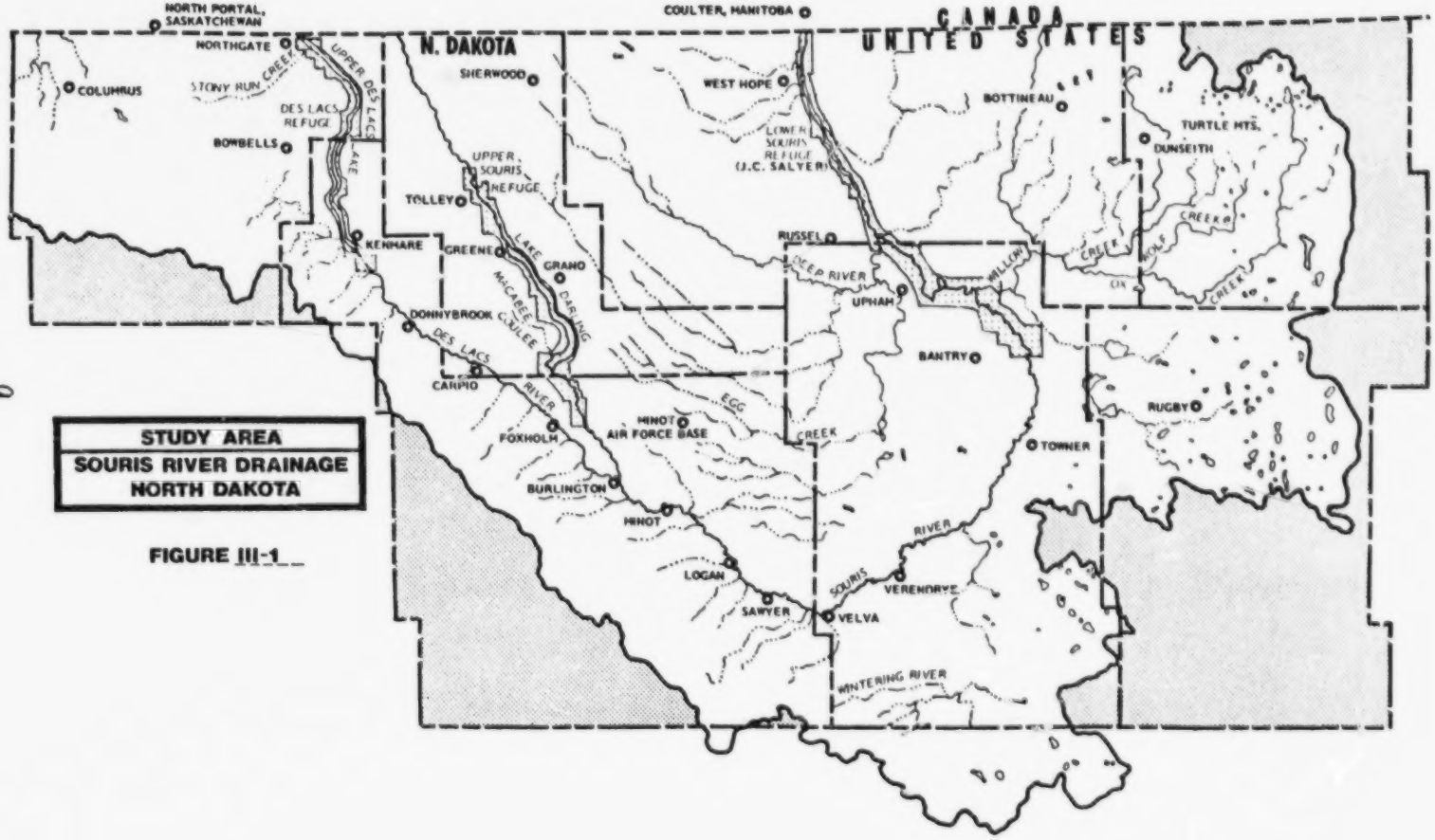

NORTH PORTAL, SASKATCHEWAN
COULTER, MANITOBA
CANADA
UNITED STATES
N. DAKOTA
NORTHGATE
COLUMBUS
STONY RUN CREEK
DES LACS REFUGE
BOWBELLS
UPPER DES LACS LAKE
SHERWOOD
WEST HOPE
LOWER SOURIS REFUGE (J.C. SALYER)
BOTTINEAU
TURTLE MTS.
DUNSEITH
UPPER SOURIS REFUGE
TOLLEY
KENMARE
GREENE
LAKE DARLING
GRANO
McGAREE COULEE
DONNYBROOK
DES LACS RIVER
CARPIO
FOXHOLM
MINOT AIR FORCE BASE
BURLINGTON
MINOT
LOGAN
SAWYER
VELVA
SOURIS RIVER
VERENDRYE
WINTERING RIVER
EGG CREEK
RUSSEL
DEEP RIVER
UPHAM
BANTRY
TOWNER
RUGBY
WILLOW CREEK
ONE CREEK
STUDY AREA
SOURIS RIVER DRAINAGE
NORTH DAKOTA

FIGURE III-1

January and February. Rainfall was below average for May and August but far above normal for June and July. These deviations from usual precipitation patterns affected streamflows as discussed in the following section.

Water quality sampling was conducted during the month of July. Precipitation data for this period from selected stations are shown in Table III-1. For the month of July, temperatures throughout the Basin were generally about three degrees below normal with daily high temperatures averaging 77.5°F. and daily low temperatures averaging 54.0°F.

TABLE III-1

PRECIPITATION DATA FOR JULY SAMPLING PERIOD

Date	Station Location (Precipitation in inches)		
	Kenmare	Minot	Westhope
July 1	T*		
3	T	0.26	0.16
4	0.05	0.62	0.43
5	T	0.02	0.02
6	0.64	0.32	0.34
7	0.65	0.57	0.30
8	0.31	0.08	0.07
9	0.15	-	0.42
10			
11			
12			
13	T	0.04	0.01
14	0.38	0.08	0.30
15	0.02	-	T
16	T	T	T
17	0.06	-	T
18	0.37	0.36	0.38
19			
20	T	-	-
21			
22	0.09	0.31	0.03
Monthly Total	3.06	3.12	2.59

*Trace

C. STREAMFLOW

Streamflow is presently measured at six gaging stations on the Souris River operated by the U.S. Geological Survey. Two gages are located near the river crossings of the International Boundary in the vicinities of Sherwood and Westhope, North Dakota. A third gage, for which streamflow data are available beginning in 1903, is located upstream from Minot. The three remaining gaging stations are located within wildlife refuges and are maintained by the Bureau of Sports Fisheries and Wildlife (BSFW) personnel.

Souris River drainage at Minot averages 97,000 acre-feet annually; however, extreme variations in seasonal and annual runoff occur. On the average, 62 percent of the annual runoff occurs during late

Spring and early Summer. The maximum annual runoff recorded at Minot during a 66-year period occurred in 1904 and amounted to 685,200 acre-feet of which 560,000 acre-feet were attributable to the spring flood. Since the closure of Lake Darling in 1936, the highest annual runoff occurred in 1969 with 363,084 acre-feet passing the Minot gage. The lowest recorded annual runoff at Minot during the 66-year period was 939 acre-feet in 1937. Zero flows have been recorded during many summer months.

Souris River flows during dry weather periods are primarily controlled by releases from Lake Darling. During periods of heavy rainfall or snow melt, runoff from the various tributaries and coulees can greatly affect flows in the Souris River. The major flood of April 1969 resulted from such effects.

Unusual rains in the fall of 1968 had filled normally dry depressions (potholes) in the prairies of Saskatchewan. A lack of early snow had also resulted in deeply frozen ground resistant to infiltration. Above normal temperatures in April 1969 in the Des Lacs watershed and Upper Souris Basin in Canada melted the winter snowpack at an unusually rapid rate. These factors combined to cause severe flooding in the Souris River Basin and a major disaster at Minot.

As a result of the April flood and above-average rainfall during June and July, streamflow during the July water quality sampling period was still far above seasonal averages. Average daily streamflows at six locations on the Souris River for the sampling period are shown in Table III-2.

TABLE III-2

AVERAGE DAILY STREAMFLOW (CFS)
JULY 7-16, 1969

Date July	Station Number	SR- 1	SR- 2	SR- 3	SR- 6	SR- 8	SR-10
	River Mile from downstream Canadian Border	321.5	267.4	232.5	161.0	73.4	7.9
7	Flow	79	101	238	379	447	273
8		131	153	578	357	449	269
9		184	160	500	315	447	265
10		193	163	487	389	449	262
11		267	163	450	542	445	319
12		270	166	400	560	435	490
13		246	170	350	530	449	526
14		327	191	300	473	483	547
15		329	265	300	393	510	559
16		326	416	400	344	519	547
	Maximum	326	416	578	560	519	547
	Minimum	79	101	238	315	435	262
	Average	235	195	400	428	463	405

D. WATER MANAGEMENT

Three migratory waterfowl refuges were constructed in the Basin during 1935 and 1936 by the U.S. Biological Survey (now Bureau of Sport Fisheries and Wildlife). The Des Lacs National Wildlife Refuge was created on the upper Des Lacs River by the construction of a series of eight low-head dams near Kenmare, North Dakota, to regulate water levels. Upper Des Lacs Lake, the largest and uppermost impoundment, provides some flow regulation for downstream impoundments.

A series of three low-head structures and a large impoundment known as Lake Darling are the main features of the Upper Souris National Wildlife Refuge located on the Souris River north of Minot. Major features of the J. Clark Salyer Wildlife Refuge (also known as the Lower Souris National Wildlife Refuge) located on the lower Souris River a few miles upstream from the International Border are six water level control structures and impoundments.

Lake Darling, with a storage capacity of 112,000 acre-feet, is the main storage reservoir for the Souris River system. The reservoir is operated for detention of flood flows, storage of excess inflow for regulation of stream flow to downstream refuge units, and release of water to downstream users with established water rights. During flood periods, releases from the reservoir are governed by inflow and regulated to minimize high water stages at downstream areas. Lake Darling releases are coordinated with discharges from the Des Lacs Refuge and other downstream tributaries.

Measures approved by the International Joint Commission provide that, except during periods of severe drought, a regulated flow of 20 cubic feet per second will be permitted to flow into Manitoba during the months of June to October, inclusive. In periods of severe drought the regulated flow may be reduced to 10 cubic feet per second or less by agreement of the International Souris River Board of Control. The measures further provide that the flow in the Souris River entering the United States at Sherwood Crossing shall not be less than four cubic feet per second when that much flow would have occurred in the Saskatchewan portion of the Basin prior to the construction of Boundary Dam on Long Creek.

The Eaton Flood Irrigation Project may divert up to 10,000 acre-feet of the spring flow from the Souris River at the project point of diversion near Towner, North Dakota. A one-time release of seasonal water temporarily detained in Lake Darling may be requested to fulfill the 10,000 acre-feet allocation. Water users with flow rights are not entitled to storage water in which the Federal government has vested rights. In addition to the Eaton Project, water is also supplied to the City of Minot for municipal use under a water sales contract arrangement.

E. POPULATION AND ECONOMY

The 1970 population of the United States portion of the Souris River Basin was estimated to total 105,000. With the exception of Minot, North Dakota, 1970 population of 32,290, the communities of

the Basin are small. Crosby, Velva and Kenmare are the only other communities exceeding 1,000 in population. Rural communities are sparsley populated.

Agriculture and mining form the economic base of much of the Basin. Service industries associated with the Minot Air Force Base and its civilian government workers are important sectors of the economy in the Minot area. Principal crops grown are small grains. Principal manufacturing operations are processing of food products. Completion of the proposed Garrison Diversion Irrigation Project would bring a supplemental water supply to the Basin and stimulate the agricultural sectors of the economy.

CHAPTER IV. SOURCES OF POLLUTION

A. MUNICIPAL AND INDUSTRIAL WASTE SOURCES

With the exception of Minot, the communities scattered throughout the United States portion of the Souris River Basin are small and produce limited quantities of municipal wastes. There are only seven sources of municipal waste large enough to potentially produce significant water quality degradation in receiving streams. The only significant source of industrial waste is a cheese factory at Towner which is located in the Basin outside the Minot area. All industrial wastes in the Minot area are discharged to the municipal system. Significant municipal and industrial waste sources are listed in Table IV-1. The present status of waste treatment for each source and conditions observed during inspections made in the summer of 1969 are discussed in the following paragraphs. Waste sources are discussed in sequence moving downstream.

TABLE IV-1

MUNICIPAL AND INDUSTRIAL WASTE SOURCES

Location	Population	Waste Treatment Facility	Receiving Stream
Crosby	1,759	Waste Stabilization Lagoon	Long Creek
Columbus	672	Imhoff Tank	Short Creek
Kenmare	2,463	Waste Stabilization Lagoons	Middle Des Lacs Lake
Minot	32,290	Waste Stabilization Lagoons	Souris River
Velva	1,330	Waste Stabilization Lagoons	Souris River
Towner	948	Waste Stabilization Lagoons	Souris River
Winger Cheese Company	-	Pretreatment and Whey Drying	Souris River
Minot Air Force Base	-	Waste Stabilization Lagoons	Egg Creek

Crosby, North Dakota

The community of Crosby is located in the extreme western portion of the Basin about six miles from the Canadian border. Untreated wastes from this source were discharged to a natural swampy area on the west edge of the community.

The site inspection indicated that this swamp does not perform as an adequate sewage lagoon. Waste are discharged to one corner of the water area which had a pinkish color. Considerable float-

ing solids were present.

The drainage pattern in the Crosby area is poorly defined. Long Creek, an intermittent stream, is located about three miles north of Crosby and flows into Canada about 10 miles east of the community. If a satisfactory waste stabilization lagoon or other treatment facility were provided, the water quality impact of this source should be negligible.

Columbus, North Dakota

This small community is located about 22 miles east of Crosby and six miles from Canada. Wastes from this community receive primary treatment in a covered Imhoff tank before discharge to a tributary of Snort Creek, an intermittent stream which flows into Canada about 10 miles northwest.

Inspection of the facility indicated that the tank was receiving regular attention. The tank vents were clean and no solids accumulation was observed in the settling zones. However, during tank cleaning, accumulated solids had been shoveled over the outfall weir into the effluent stream. Proper disposal of this material should be provided to minimize the water quality impact of this source.

Both Crosby and Columbus are remotely located with respect to the United States section of the Souris River. Therefore, these sources have no effect on the quality of the Souris River and were not sampled in this study.

Kenmare, North Dakota

Until 1970, this community discharged untreated wastes through a main outfall and a number of storm drains to the Middle Des Lacs Lake. Except during periods of drought, the Des Lacs River flows through this impoundment providing some dilution of waste discharges. The waste discharges had degraded water quality in the vicinity of the outfalls resulting in low levels of dissolved oxygen, sludge deposits and damage to aquatic life. Intense algal blooms have also occurred.

The community completed a waste stabilization lagoon in 1970 which should alleviate water quality degradation resulting from the discharge of solids and oxygen demanding materials to Middle Des Lacs Lake. The treatment facilities will not substantially reduce the discharge of nutrients.

Minot, North Dakota

Treatment facilities for the City of Minot consist of a two-celled waste stabilization lagoon. At the time of the study, effluent from the lagoon was discharged to a dry coulee and did not reach the Souris River. Thus, this discharge had no measurable effect on water quality in the river system.

Facilities have recently been completed to divert the lagoon effluent directly to the Souris River. This diversion was accomplished to allow the city to receive credit for the return flow and increase the amount of water diverted for municipal uses. Direct discharge of the treated effluent to the river will increase the nutrient load carried by the river system and produce some water qual-

ity degradation. Water quality conditions downstream from Minot have not been evaluated since the discharge began.

Velva, North Dakota

Until 1970, the City of Velva discharged untreated municipal wastes directly to the Souris River with adverse effects on water quality during low flow periods. Five-day biochemical oxygen demands as high as 424 mg/l and fecal coliform counts as high as 3.6 million per 100 ml were observed in this waste discharge. High bacterial concentrations, depressed dissolved oxygen levels and unesthetic conditions were produced in the river. The city has recently constructed a waste stabilization lagoon. The water quality impact of the treated effluent has not been evaluated.

Towner, North Dakota

At the time of the field investigations, the largest discharge of wastes to the Souris River system was located at Towner. Municipal wastes from the city and industrial wastes from the Winger Cheese Company were discharged to the river without treatment. The cheese company, which employed about 30 persons and produced about 25,000 pounds of cheese and 12,000 pounds of dried whey per day, discharged an estimated one million gallons per month of strong industrial wastes to city sewers without treatment. An extremely high five-day biochemical oxygen demand of 24,000 mg/l and fecal coliform concentrations of 8.6 million per 100 ml were measured in the waste discharge at Towner.

Water quality degradation below Towner was the most severe observed during the field investigations. This degradation persisted for many miles downstream. Large growths of the sewage slimes, Sphaerotilus natans, were observed in the five mile reach below the outfall.

A total fish kill in a seven mile reach below Towner was reported in April 1968.

During the Fall of 1969, the city constructed and placed into operation a two-celled waste stabilization lagoon. The Winger Cheese Company also constructed pretreatment facilities to reduce the concentrations of oxygen demanding waste solids discharged in its industrial wastes. When observed in March 1970, all wastes from the city and the cheese company were being discharged to the lagoon and the industrial waste pretreatment facilities were being operated. The adequacy of present waste treatment facilities has not been evaluated.

Minot Air Force Base

Treatment facilities for this military installation consist of a large waste stabilization lagoon. Lagoon area was expanded from 105 to 257 acres in 1969. This enlarged facility should provide adequate treatment for wastes from this source.

Effluent from the lagoon is discharged to Ego Creek which flows into North Lake about 25 miles east of the air base. Since this waste source is remote, it has no measurable impact on water qual-

ity in the Souris River.

Lignite Mining Areas

Surface mining activities for lignite coal is a potential source of pollution. It is currently underway in an area south of Sawyer, North Dakota. Several small streams draining this area were investigated for possible pollution in July 1969. Runoff from these mining areas did not appear to be causing a stream pollution problem although it is obvious that a high potential for erosion has been created by removal of terrestrial vegetation. No acid drainage was observed such as commonly results from bituminous coal stripping operations. All pH values of the streams checked were in the range of 8.0 to 8.5.

B. AGRICULTURAL SOURCES

Animal Wastes

Several animal feedlots are located adjacent to the Souris River upstream from Minot and also in the vicinity of Velva. Feedlots contribute nutrients, organic materials and high concentrations of bacteria to the river, especially during periods of surface runoff. Other feedlots more remote from the river contribute pollution through surface runoff. It is recommended that effluent from feedlot operations without treatment be excluded from surface streams.

Irrigation Return Flows

If irrigation water is applied to cropland in excess of the amount actually utilized by growing crops, excess water percolates to the groundwater system and/or moves overland to the stream system as surface runoff. Surface return flows finding their way to the stream system may contain significant quantities of pollutants such as pesticides, sediments, organic debris and nutrients. Subsurface return flows, which usually are delayed in movement through aquifers, may contain significant quantities of nutrients and dissolved solids in addition to the materials contained in the applied irrigation water. Irrigation return flows currently are not believed to be significant source of water quality degradation in the Souris Basin. However, completion of the proposed Garrison Diversion Irrigation Project would substantially increase the volume of return flows reaching the river system with an attendant increase in pollution potential.

Rural Runoff

In addition to the pollution contributed by animal feedlots and irrigation return flows, surface runoff from rural areas can cause significant pollution, especially in areas of intensive farming activity. Sediments are the most significant cause of water quality degradation. Pesticides and nutrients leached from fertilizers may also cause water quality problems. Water quality degradation resulting from rural runoff has not been defined for the Souris River Basin but is assumed to con-

tribute to overall water quality conditions in farming areas.

C. WILDLIFE REFUGES

Due to the shallow and sluggish characteristics of the refuge impoundments in combination with high nutrient concentrations found throughout the river system, lush growths of emergent aquatic vegetation and frequently intense algal blooms occur. Algal blooms and other plant growths remove nutrients from the water which may be incorporated into bottom sediments when the plants die and settle to the bottom. Some nutrients, especially phosphorus, may be adsorbed on to the surface of sediment particles which settle out and add to bottom sediments.

Large amounts of organic detritus present in the refuge impoundments exerts an oxygen demand as it decays which reduces dissolved oxygen concentrations in the impoundments. These organic materials also contribute to high background biochemical oxygen demand which reduces the assimilative capacity of the river system. Oxygen depletion by organic materials is most significant during warm weather, low flow periods.

Decay of organic materials releases nutrients to the overlying waters. Wind and resultant wave action and currents can stir up bottom sediments with their store of nutrients, allowing recycling of these nutrients into additional plant growth. Under above-normal streamflow conditions, nutrients released in the impoundments may be carried downstream and the refuge would serve as a nutrient source.

Blooms of blue green algae are known to be sources of taste and odor in municipal water supplies. Blue-green algal blooms occur in both the Upper Souris and Des Lacs Wildlife Refuges upstream from Minot and are believed to contribute to taste and odor problems in the Minot municipal supply.

The refuges serve as resting areas for large flocks of waterfowl during the spring and fall migrations. These concentrations of waterfowl produce fecal contamination of refuge waters with increases in bacterial and nutrient concentrations, and biochemical oxygen demand. The magnitude of these effects was not quantified during this survey.

CHAPTER V. FIELD INVESTIGATIONS

Three sets of field investigations were conducted during June-October, 1969. These investigations included two biological surveys and a short term chemical and microbiological survey of a large number of stream stations and a few waste effluents. The scope of the various investigations, station locations, parameters evaluated, and methods of analysis are discussed in the following sections.

A. BIOLOGICAL SURVEYS

Biological surveys were conducted during two periods; June 5-21 and October 1-10, 1969. These surveys were designed to evaluate biological conditions existing both before and during the fall waterfowl migration. For this reason, a number of stations were surveyed in the various refuges as well as in the stream reaches affected by waste discharges.

Biological Sampling Stations

Biological sampling was conducted at 24 stations located on the United States portion of the mainstem Souris River, at two stations on the Souris River in Canada near the border and at eight stations on the Des Lacs River. Station designations and locations are listed in Table V-1. Station locations are listed in downstream order by river mile which is the distance along the river in miles upstream from the point where the Souris River enters Manitoba, Canada. Locations of both the biological sampling stations and the water quality stations discussed in a later section are shown in Figure V-1.

Survey Methodology

The biological surveys included qualitative and quantitative evaluations of populations of benthos (bottom-dwelling invertebrates) and phytoplankton (suspended algae). Bottom sediments were also examined chemically.

Benthos samples were collected with either a Petersen or Ekman dredge depending upon the depth of the water and firmness of the substrate. Qualitative samples were collected by hand from log jams or riffle areas. Samples were washed through a number 30 U. S. standard mesh sieve and material retained on the sieve was preserved with formalin to effect a 10 percent solution.

Phytoplankton collections were preserved with 4 percent formalin and stored in 1 liter containers. Identification and counting of the phytoplankton using a Sedwick-Rafter cell followed the procedure outlined in "Standard Methods"[1]. Conversion of the numbers of phytoplankton to parts per million (wet algal volume) was determined by microscopic measurement of predominate cells and conversion to parts per million by the following formula:

TABLE V-1

SAMPLING STATION LOCATIONS

Chemical and Bacteriological Station Number	Biological Station Number	River Mile	Location
		Souris River	
	USC-1	358.2	Souris River near North Portal, Saskatchewan
	US-1	353.5	
	US-3	326.7	
SR-1		321.5	Souris River at State Route 5, North of Tolley
	US-4	320.5	
	LD-1	305.8	Lake Darling
	LD-2	295.6	Lake Darling
	LD-3	278.4	Lake Darling
	S-1	275.3	Below Lake Darling Outflow Structure
SR-2	S-3	267.4	Foxholm (Monitor)
	S-4	243.5	
SR-3		232.5	Souris River Below Water Plant Dam at Minot
	S-6	228.9	
SR-4	S-9	222.1	Souris River at U. S. 2 Bypass at Minot
SR-5	S-11	197.6	Souris River at Sawyer
	S-13	185.6	
SR-6a		185.0	Velva Sewage Effluent
SR-6	S-15	161.0	Souris River at Verendrye
SR-7	S-17	108.0	Souris River at State Route 14 near Towner
	S-18	101.9	
SR-9a	S-19	101.5	Towner Sewage Effluent
	S-20	98.7	
SR-8a		88.0	Monitor Downstream of Towner
	S-21	80.1	
SR-8	S-23	78.4	Souris River East of Bantry
	S-25	52.3	
	S-27	48.6	
	S-28	42.4	
	S-33	32.1	
SR-9		31.8	Souris River East of Russell
	S-34	21.6	
	S-35	16.7	
SR-10	S-37	7.9	Souris River East of Westhope
SR-11a		7.0	Westhope Lagoon Effluent
	S-40	1.0	
	S-41	-1.0	Canadian Border near Coulter, Manitoba
		Tributaries	
MC-1		278.4	Mackobee Coulee off Lake Darling
SC-1		243.7 + 55.6	Stony Run Creek at Recreation Dam
DR-1		243.7 + 48.8	Upper Des Lacs Lake near Northgate
	DL-1	243.7 + 40.3	Upper Des Lacs Lake
	DL-3	243.7 + 36.2	Upper Des Lacs Lake
DR-2		243.7 + 35.4	Middle Des Lacs Lake at North Edge Kenmare

TABLE V-1 (Continued)

SAMPLING STATION LOCATIONS

Chemical and Bacteriological Station Number	Biological Station Number	River Mile	Location
	Tributaries (Continued)		
	DL-4a	243.7 + 35.0	Middle Des Lacs Lake near Kenmare Outfall
	DL-4b	243.7 + 34.5	Middle Des Lacs Lake
	DL-5	243.7 + 34.0	Middle Des Lacs Lake
DR-3		243.7 + 30.2	Des Lacs River Downstream from Lower Des Lacs Lake
	DL-8	243.7 + 29.5	Des Lacs River at Carpio
	DL-11	243.7 + 24.5	
	DL-17	243.7 + 1.5	Des Lacs River near Mouth
DC-1		37.3	Deep River near Mouth

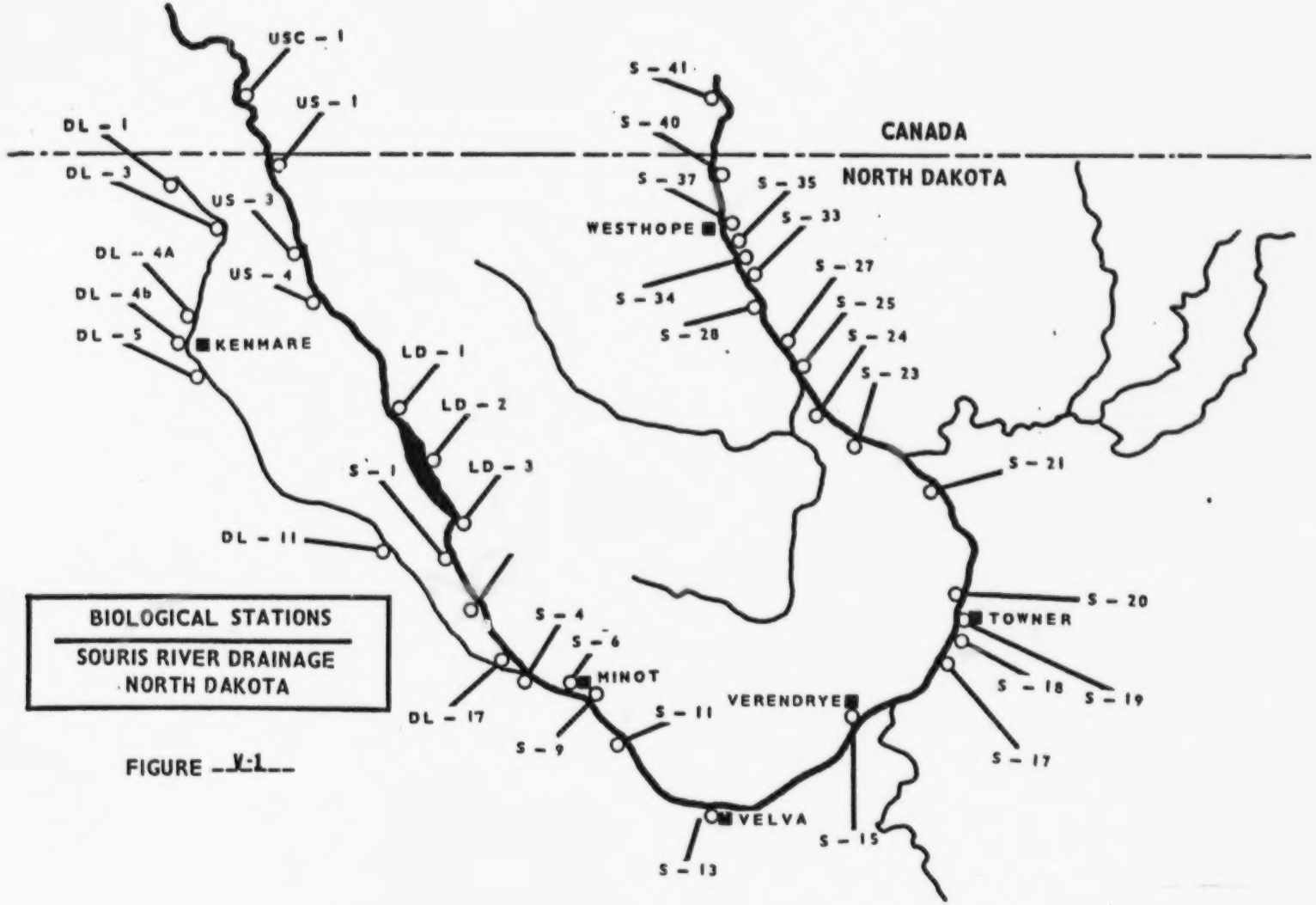

USC – 1
US – 1
DL – 1
DL – 3
US – 3
DL – 4A
US – 4
DL – 4b
DL – 5
KENMARE
LD – 1
LD – 2
LD – 3
S – 1
DL – 11
S – 4
S – 6
MINOT
DL – 17
S – 11
S – 9
VELVA
S – 13
S – 15
VERENDRYE
S – 17
S – 18
S – 19
TOWNER
S – 20
S – 21
S – 23
S – 24
S – 25
S – 27
S – 28
S – 34
S – 33
S – 35
S – 37
WESTHOPE
S – 40
S – 41
CANADA
NORTH DAKOTA
BIOLOGICAL STATIONS
SOURIS RIVER DRAINAGE
NORTH DAKOTA

FIGURE V-1

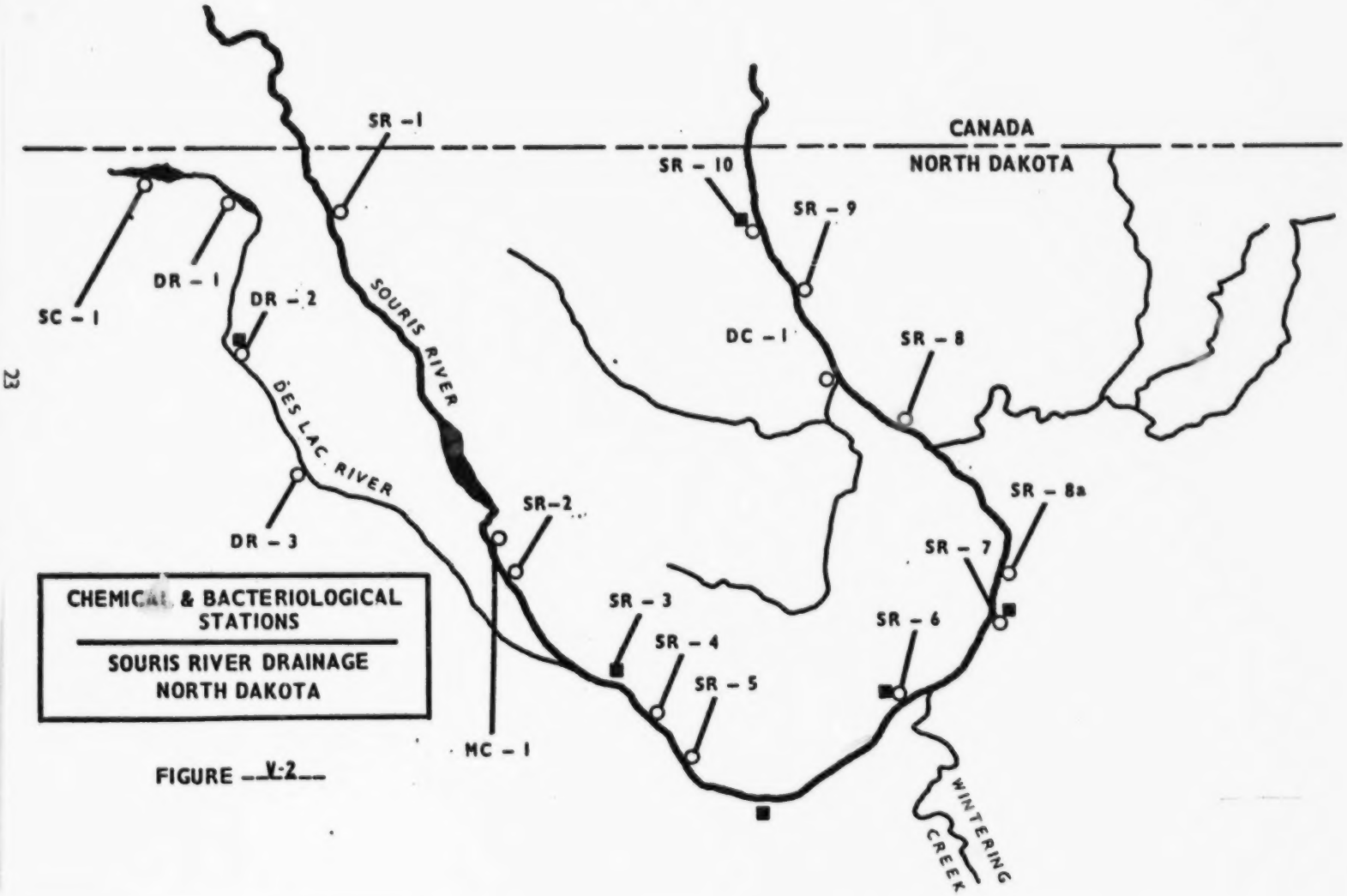

CANADA
NORTH DAKOTA
SR – 1
SR – 10
SR – 9
SR – 8
SR – 8a
SR – 7
SR – 6
SR – 5
SR – 4
SR – 3
SR–2
DC – 1
SC – 1
DR – 1
DR – 2
DR – 3
SOURIS RIVER
DES LAC RIVER
MC – 1
WINTERING CREEK
CHEMICAL & BACTERIOLOGICAL STATIONS
SOURIS RIVER DRAINAGE
NORTH DAKOTA

FIGURE V-2

Wet algal volume (ppm) = Number of organisms per milliliter x average species volume in cubic microns x 10^{-6}.

Sediment samples were collected by dredging and placed in a wash tub, taking care not to disturb the top layers. These layers were then removed and placed in a plastic bag and frozen. Analysis of these sediments for organic carbon was performed according to the procedures in "Standard Methods" and Ballinger and McKee (5). Analysis for total phosphorus and organic nitrogen was achieved by adopting "Standards Methods" procedures for use on sediments.

B. CHEMICAL AND MICROBIOLOGICAL SURVEY

A survey of water quality conditions in the Souris River and its tributaries was conducted during the period July 5-20, 1969. Several waste sources were also sampled during this period. The survey was designed to define general water quality conditions and assess the impact of waste sources on water quality.

Sampling Stations

Water quality grab samples were obtained from a total of ten stations on the Souris River and six stations on major tributaries. Four waste effluents were also sampled. In addition, continuous water quality monitoring for a 2-day period was conducted at two locations on the Souris River. Station designations and locations are listed in Table V-1. Station locations are also shown on Figure V-1. The number of samples obtained from each station is shown in Table V-2.

Water Quality Parameters Evaluated

A total of nine water quality parameters were routinely evaluated at all stream sampling stations. In addition, all stations were intermittently sampled for several more parameters and detailed chemical analyses were performed on samples from four stations. Sampling frequency and parameters evaluated at each of the stream stations are shown in Table V-2.

A continuously recording water quality monitor was operated for 45 hours during the July 15-17, 1969, period at Station SR-8a (River Mile 88.0) located about 3.5 miles downstream from Towner. Continuous recordings of dissolved oxygen and conductivity along with a short temperature record were obtained. The monitor was operated at Station SR-2 (River Mile 267.4) downstream from Lake Darling during July 18-20, 1969, period. Thirty-five hour continuous recordings of pH, dissolved oxygen, conductivity, and water temperature were obtained.

Analytical methods used for chemical determinations conformed to "FWPCA Official Interim Methods for Chemical Analysis of Surface Waters"(3). Where needed, modifications were made for automated chemical analyses. Heavy metal analyses were performed by atomic absorption spectrophotometry. Bacterial determinations were performed in accordance with "Standard Methods"(1).

TABLE V-2

CHEMICAL AND BACTERIOLOGICAL ANALYSES SCHEDULE

Parameter	Station Designation															
	SR-1	SR-2	SR-3	SR-4	SR-5	SR-6	SR-7	SR-8	SR-9	SR-10	DR-1	DR-2	DR-3	MC-1	DC-1	SC-1
Temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Biochemical Oxygen Demand	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Conductivity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total Coliform (MF)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fecal Coliform (MF)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Nitrate-Nitrogen (NO_3-N)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Total Phosphorus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Orthophosphate (Soluble P)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chlorides	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sulfates	X	X	X	X	X	X	X	X	X	X	X	-	X	-	-	-
Iron	X	-	-	-	-	X	-	-	-	X	-	-	X	-	-	-
Manganese	X	-	-	-	-	X	-	-	-	X	-	-	X	-	-	-
Calcium	X	-	-	-	-	X	-	-	-	X	-	-	X	-	-	-
Magnesium	X	-	-	-	-	X	-	-	-	X	-	-	X	-	-	-
Silica	X	-	-	-	-	X	-	-	X	X	-	-	X	-	-	-
Sodium	X	-	-	-	-	X	-	-	-	X	-	-	X	-	-	-
Sampling Period (Days)	10	10	8	2	10	10	10	10	10	10	10	5	10	5	5	5

CHAPTER VI. WATER QUALITY EVALUATIONS

A. APPLICABLE WATER QUALITY STANDARDS

Water quality standards applicable to the interstate and international waters of North Dakota (including the Souris and Des Lacs Rivers) were established by the State Department of Health on June 30, 1967, in accordance with the Federal Water Pollution Control Act as amended by the Water Quality Act of 1965. These standards were subsequently approved as Federal standards by the Secretary of the Interior on August 7, 1967. A revision of the standards was accomplished by the State Department of Health in 1969. The revised standards were approved by the Federal Water Quality Administration on May 22, 1970.

Approved standards consist of three components: (1) Stream classifications which designate the water uses to be protected in a given stream reach; (2) Water quality criteria which specify limits on various physical, chemical and microbiological parameters which must be met for each stream classification; and (3) An implementation plan which establishes schedules for completion of necessary treatment facilities by waste sources presently providing inadequate treatment. These standards are reproduced in Appendix A.

Waters of the Souris and Des Lacs Rivers were classified for the following uses: (1) Municipal water supplies; (2) Industrial water supplies, including food processing; (3) Recreation, fish and wildlife; and (4) Agricultural uses[2]. The standards did not differentiate between primary contact recreation (swimming) and secondary contact recreation (wading and water skiing) in the stream classifications. However, the bacteriological criteria established by North Dakota would provide water quality suitable for primary contact recreation in Lake Darling and secondary contact recreation in other waters as required by National Technical Advisory Committee criteria.

B. WATER QUALITY CONDITIONS

Souris River basin waters receive only small volumes of industrial wastes The standards include maximum or minimum values for dissolved oxygen, biochemical oxygen demand, water temperature and pH provided a good outline of water quality conditions as affected by municipal waste discharges. Due to the eutrophic state of the river system, inorganic nutrient paramenters were also evaluated. Inorganic constituents such as sulfates, chlorides, sodium, calcium, plus magnesium were measured to provide a basis for evaluating the impact of future irrigation developments. Bacteriological densities were measured to indicate the sanitary condition of waters used for water supplies.

DISSOLVED OXYGEN

Dissolved oxygen (DO), is a vital constituent of the aquatic environment, essential to the maintenance of aquatic life and esthetic values. A lack of DO results in septic conditions which will adversely affect water uses.

DO concentrations in water are interrelated with water temperature, incident light, which affects photosynthetic production and the concentration and rate of decomposition of organic material present in the water. Oxygen enters the aquatic environment by solution from the atmosphere and by plant photosynthesis and is removed by organism respiration and biochemical oxidation of organic materials.

Water quality standards applicable to the Souris and Des Lacs Rivers specify that DO concentrations shall be "Not less than 5 mg/l at any time in Lake Darling Reservoir. Not less than 5 mg/l for any 16 hours of the day nor any measured readings less than 4 mg/l at any time in the stream."(2)

Dissolved oxygen concentrations were determined for a total of 16 locations on the Souris River and its tributaries during the 10-day survey from July 7 to 16, 1969. DO analyses were made on grab samples obtained during the morning hours, usually between 6:30 and 11:30 A.M. The results of the DO analyses are summarized in Table VI-1.

In addition to the grab sampling, continuously recording water quality monitors were operated for short periods at two locations: Downstream from Lake Darling; and Downstream from the Towner sewage outfall. Monitor data are summarized in Tables VI-2 and VI-3.

Observed DO concentrations at eight of the ten Souris River stations sampled met or exceeded applicable standards. DO levels at these stations ranged from 4.0 to 12.5 mg/l with average values at most stations exceeding 6 mg/l. At River Mile (RM) 73.4, about 28 miles downstream from Towner, DO levels were depressed by the effects of the large discharge of untreated wastes at Towner. All samples at this location were below the required 5 mg/l minimum limit. The Towner waste discharge thus violated DO standards at this location.

Violations of DO standards also occurred at RM-31.8 (Sta. SR-9) in the J. Clark Salyer Wildlife Refuge. DO concentrations at this location ranged from 1.4 to 5.9 mg/l with an average of 3.1 mg/l. Depressed DO levels at this location were believed to be the result of combination of a die-off of an algal bloom and decaying vegetation as well as the residual effects of the Towner waste discharge. This station is located in a shallow, sluggish impoundment.

Dissolved oxygen data generated by the water quality monitors differed sharply between the two stations sampled. At RM-267.4 (Sta. SR-2) below Lake Darling, observed DO levels ranged from 5.3 to 7.4 mg/l (See Table VI-3). The DO concentrations exhibited typical diurnal fluctuations, reaching a daily minimum shortly after sunrise as a result of biotic respiration during the night and reaching a daily maximum near sundown following a period of maximum photosynthetic activity. At RM-88.0 (Sta. SR-8a) about 3.5 miles below the Towner outfall, recorded DO concentrations were very low, ranging from 0.2 to 4.4 mg/l (See Table VI-2). DO levels exhibited duirnal fluctuations similar to the upstream monitor location but with a much larger range. Minimum concentrations at this location were the lowest observed in the survey and constituted gross violations of DO standards. This violation is the direct result of the Towner waste discharge.

TABLE VI-1

DISSOLVED OXYGEN, TEMPERATURE, pH AND TURBIDITY DATA
July 7-16, 1969

Station	River Mile	Number of Samples	Dissolved Oxygen mg/l			Average Value		Turbidity JTU
			Maximum	Minimum	Average	Water Temperature °C	pH	
				SOURIS RIVER				
SR-1	321.5	10	10.4	5.9	7.7	18.5	8.0	6.7
SR-2	267.4	10	8.1	6.8	7.5	19.2	8.2	3.4
SR-3	232.5	8	7.0	5.9	6.6	21.0	7.8	30
SR-4	222.1	2	6.4	6.1	6.2	19.0	8.0	50
SR-5	197.6	10	6.6	5.6	5.9	20.0	7.9	41
SR-6	161.0	10	7.1	5.5	6.7	20.0	7.9	30
SR-7	108.0	10	6.4	4.0	5.3	20.0	7.9	18.8
SR-8	73.4	10	4.8	2.8	4.0	20.0	7.9	9.5
SR-9	31.8	10	5.9	1.4	3.1	20.0	7.9	4.4
SR-10	7.9	10	12.5	8.0	10.1	20.0	8.6	5.3
				TRIBUTARIES				
SC-1	243.7 + 55.6	5	7.0	5.9	6.4	20.0	7.5	3.6
DR-1	243.7 + 48.8	10	7.3	6.1	6.6	19.0	7.8	9.3
DR-2	243.7 + 35.4	5	5.0	1.4	3.6	21.2	7.8	8.4
DR-3	243.7 + 30.2	10	6.0	1.4	2.5	18.6	7.6	4.7
MC-1	278.4	5	7.0	2.1	4.4	20.0	7.7	3.8
DC-1	37.3	5	5.8	1.9	3.7	20.0	8.2	5.6

TABLE VI-2

WATER QUALITY MONITOR DATA
River Mile-88.0

Date 1969	Time	pH	Dissolved Oxygen* mg/l	Conductivity Micromohos/cm at 25°C	Water Temperature °C
15 July	1200	-	1.3	860	----
	1400	-	2.1	865	----
	1600	-	3.6	870	----
	1800	-	4.4	865	----
	2000	-	4.3	845	----
	2200	-	3.5	815	----
	2400	-	2.6	785	----
16 July	0200	-	2.0	755	----
	0400	-	1.2	760	----
	0600	-	1.3	760	----
	0700	-	0.9	---	----
	0800	-	0.5	770	----
	1000	-	0.2	795	----
	1200	-	0.7	815	----
	1300	-	1.1	---	----
	1400	-	1.7	840	----
	1600	-	2.6	840	----
	1800	-	3.1	855	----
	2000	-	3.1	850	----
	2200	-	3.0	840	----
	2400	-	2.9	825	----
17 July	0200	-	2.7	815	23.8
	0400	-	2.1	805	23.6
	0500	-	1.4	---	----
	0600	-	0.9	805	23.3
	0800	-	1.0	805	23.3
	0900	-	1.3	---	----

* All Dissolved Oxygen values violate Federal Standards.

TABLE VI-3

WATER QUALITY MONITOR DATA
River Mile-267.4

Date 1969	Time	pH	Dissolved Oxygen mg/l	Conductivity Micromohos/cm at 25°C	Water Temperature °C
18 July	1800	8.65	7.2	430	24.1
	2000	8.60	7.4	435	23.8
	2200	8.55	6.7	435	23.6
	2400	8.45	6.5	440	23.3
19 July	0200	8.35	6.0	440	23.0
	0400	8.35	5.8	440	23.0
	0600	8.30	5.4	445	23.0
	0800	8.30	5.3	445	23.0
	1000	8.30	5.5	445	23.3
	1200	8.40	6.4	440	23.8
	1400	8.40	6.6	440	24.4
	1600	8.45	6.7	445	24.7
	1800	8.50	6.7	445	24.7
	2000	8.50	6.7	445	24.4
	2200	8.40	6.5	445	24.1
	2400	8.40	6.2	445	23.8
20 July	0200	8.35	5.8	445	23.6
	0400	8.30	5.6	445	23.6
	0500	8.30	5.3	445	23.6

At four of the six sampling stations on tributaries, violations of DO standards were measured. In Middle Des Lacs Lake near the Kenmare waste outfall (Sta. DR-2) and in the Des Lacs River downstream from Kenmare (Sta. DR-3), DO levels were depressed below applicable standards a majority of the time as a result of the discharge of untreated wastes from Kenmare. DO concentrations at these locations ranged from 1.4 to 6.0 mg/l.

DO concentrations below applicable standards were also observed in Mackobee Coulee off of Lake Darling (Sta. MC-1) and in Deep River near its confluence with the Souris River (Sta. DC-1). Mackobee Coulee is a shallow embayment of Lake Darling and low DO levels 2.1 to 7.0 mg/l at this location are believed to be the result of decaying vegetation and the die-off of algal blooms. Similar conditions exist near the mouth of the Deep River where DO concentrations of 1.9 to 5.8 mg/l were measured. This sampling point is also located in the J. Clark Salyer Wildlife Refuge near the station on the Souris River exhibiting comparable low DO levels.

At the two tributary locations meeting standards, Stony Run Creek (Sta. SC-1) and Upper Des Lacs Lake near Northgate (Sta. DR-1), observed DO levels were comparable to those found in the upper Souris River locations.

BIOCHEMICAL OXYGEN DEMAND

Organic materials from natural sources such as decaying animal and vegetative matter and the organic constituents of municipal and industrial wastes utilize dissolved oxygen from the aquatic environment during their biochemical decomposition and stabilization. The potential oxygen demand represented by the organics present in a given waste discharge or water body is commonly measured by the biochemical oxygen demand (BOD) analysis. Since BOD and the concentrations of DO in a water body are interrelated, measurement of BOD can provide basis for evaluating the impact of waste discharges and natural sources of organics on dissolved oxygen levels in receiving waters.

BOD analyses are usually conducted after incubation of samples at 20°C for 5 days. Test results are reported as the common 5-day BOD (BOD_5). Other incubation periods may also be used. For this survey, both 2-day and 5-day BOD were determined for sixteen stream stations on the Souris River and major tributaries and four waste discharges. Determination of BOD for the two different incubation periods permitted evaluation of rate constants and ultimate BOD which can be utilized for mathematical simulation of dissolved oxygen concentrations for varying stream conditions. BOD data are summarized in Table VI-4.

BOD measured at the ten Souris River stations was relatively uniform with individual BOD_5 sample values ranging from a minimum of 1.8 mg/l in Lake Darling to a maximum of 7.0 mg/l in the J. Clark Salyer Wildlife Refuge and mean BOD_5 values ranging from 2.0 to 4.4 mg/l. These BOD values were indicative of a relatively high background BOD contribution from natural sources such as the decaying organic materials present in the various refuge impoundments.

TABLE VI-4

BIOCHEMICAL OXYGEN DEMAND DATA

Station	River Mile	Number of Samples	BIOCHEMICAL OXYGEN DEMAND-mg/l at 20°C Maximum 2-Day	Maximum 5-Day	Minimum 2-Day	Minimum 5-Day	Mean 2-Day	Mean 5-Day	Rate* Constant K_1	Ultimate* Concentration L-mg/l
					SOURIS RIVER					
SR-1	321.5	10	4.0	5.2	1.2	2.2	2.1	3.4	0.17	4.0
SR-2	267.4	10	4.0	4.8	1.0	1.8	1.8	2.8	0.18	3.2
SR-3	232.5	8	2.6	3.8	1.1	3.2	1.7	3.0	0.11	4.2
SR-4	222.1	2	1.9	4.2	1.7	3.6	1.8	3.9	----	---
SR-5	197.6	10	4.2	6.0	1.2	2.6	2.2	3.9	0.11	5.4
SR-6	161.0	10	2.4	5.1	1.6	2.6	2.0	3.8	0.08	6.3
SR-7	108.0	10	2.7	4.7	1.7	2.5	2.2	3.6	0.16	4.3
SR-8	73.4	10	3.6	5.2	1.0	2.6	2.2	3.6	0.16	4.3
SR-9	31.8	10	5.4	7.0	1.3	2.1	2.3	3.3	0.23	3.5
SR-10	7.9	10	4.2	6.2	1.6	3.1	2.7	4.4	0.06	5.2
					TRIBUTARIES					
SC-1	243.7 + 55.6	5	3.1	4.6	0.8	1.3	1.8	2.6	0.22	2.8
DR-1	243.7 + 48.8	10	5.1	8.6	0.8	1.4	2.3	4.3	0.08	7.1
DR-2	243.7 + 35.4	5	4.4	7.4	2.7	5.0	3.6	6.0	0.15	7.3
DR-3	243.7 + 30.2	10	3.0	4.0	1.0	1.9	1.6	2.6	0.16	3.1
MC-1	178.4	5	3.2	4.8	1.7	2.4	2.5	3.5	0.24	3.7
DC-1	37.3	5	4.2	4.9	2.0	3.2	2.8	3.8	0.27	---
					WASTE EFFLUENTS					
SR-5a	Minot Lagoon	5	64	88	6	12	25	39	0.18	45
SR-6a	Velva	4	304	424	95	142	192	295	0.19	333
SR-9a	Towner	3	14000	24000	1550	3900	7430	11900	0.17	13,900
SR-11a	Westhope Lagoon	3	25	50	1	1	12	22	0.18	37

* Based on Mean BOD values.

Because of unusually high streamflow conditions at the time of the field survey, measured BOD values were probably lower than usual for July. The higher streamflow also provided above normal dilution of major waste discharges, producing lower BOD than would be expected under low flow conditions. At RM-73.4 (Sta. SR-8), about 28 miles downstream from the Towner waste discharge, observed BOD's were comparable to other Souris River stations located above all waste discharges.

BOD values at the six tributary locations varied primarily as a result of physical differences in the stream locations sampled. Low concentrations were observed in small headwater tributaries and high concentrations were found in sluggish impoundments. BOD_5 levels ranged from 1.3 to 8.6 mg/l. The range in mean BOD_5 concentrations was 2.6 to 6.0 mg/l.

The highest BOD_5 observed (8.6 mg/l) occurred in Upper Des Lacs Lake (Sta. DR-1). A very low value of 1.4 mg/l also occurred at this station which had an average BOD_5 (4.3 mg/l) only slightly above most survey stations. High values at this station can be attributed either to organic material in the impoundment which had been disturbed by wind and wave action or to algae concentrations which may have been present in unfiltered samples.

The highest average BOD_5 in this survey was measured in Middle Des Lacs Lake near the Kenmare waste outfall (Sta. DR-2). High values at this point were the result of untreated waste discharges from the City of Kenmare. About five miles downstream on the Des Lacs River (Sta. DR-3), average BOD_5 had decreased to 2.6 mg/l, indicating most of the Kenmare BOD load was being assimilated in Middle Des Lacs Lake.

Observed BOD values at other tributary stations were similar to those found at Souris River stations.

Samples of untreated wastes from the Towner outfall exhibited very high BOD_5 ranging from 3,900 to 24,000 mg/l with a mean of 11,900 mg/l. Industrial wastes from the Winger Cheese Factory were the cause of this high BOD. The large variation in concentrations was probably because of a combination of fluctuations in the strength of the industrial wastes and changes in the relative proportions of industrial and municipal wastes discharged to the outfall at the time of sampling. This high BOD waste source could be expected to substantially increase BOD in the Souris River during low flow periods. As previously discussed, due to the above normal streamflows, no significant residual from this waste source was measured 28 miles downstream (Sta. SR-8) during this survey. No BOD sampling station was located immediately downstream from this waste source.

Untreated wastes from the Velva outfall were found to have a BOD_5 ranging from 192 to 424 mg/l with an average of 295 mg/l. These values are typical of untreated municipal wastes. Because of the small volume of this waste discharge relative to the above normal stream flow, no residual BOD was detected at the next sampling point 24 miles downstream (Sta. SR-6).

Effluent from the Minot waste stabilization lagoons was found to have a BOD_5 averaging 39 mg/l.

At the time of the survey, the lagoon effluent was discharged to a dry coulee. The recent diversion of this effluent to the Souris River has added a significant BOD loading to the river below Minot.

BOD_5 in the Westhope waste stabilization lagoon effluent averaged 22 mg/l. The Westhope effluent is a minor source of BOD.

Since BOD in the Souris River is relatively uniform, the BOD loading carried by the river is primarily a function of stream flow. During the survey period, Souris River stream flow entering the United States averaged 230 cubic feet per second (cfs) with a BOD_5 of 3.4 mg/l and carried a BOD_5 loading of about 4,300 pounds per day. In the reach of the river near Minot, average stream flow increased to 400 cfs with a BOD_5 of 3.9 mg/l primarily as a result of the Des Lacs River inflow. The average BOD load in this reach was 8,400 pounds per day.

Souris River stream flow leaving the United States during the study period averaged 405 cfs with a BOD_5 of 4.4 mg/l, a slight increase from the flow and BOD_5 at Minot The average BOD_5 load entering Canada was 9,700 pounds per day. The BOD load discharged to the river by municipal and industrial waste sources was not evaluated.

Under the streamflow and BOD loading conditions found during the survey, the addition of the Minot Lagoon effluent to the Souris River would have increased the BOD load in the river at Minot. Under low flow conditions, both the volume of dilution water and the BOD load contributed by natural sources would be lower and the relative effects of constant man-made BOD sources such as the Minot and Towner waste discharges would be much greater. A quantitative evaluation has not been made of BOD and DO concentrations expected under low flow conditions.

INORGANIC CONSTITUENTS

Various minerals are readily soluble in water. These dissolved solids, when present in significant concentrations, may degrade water quality and affect water uses. In the Souris River Basin, dissolved solids are approaching levels which will reduce the value of the Souris River as a source for municipal and agricultural uses.

Dissolved minerals are present in water in ionic form. The concentration of a specific ion which may adversely affect water uses varies widely between different ions and different water uses. Water quality criteria applicable to basin waters do not set specific limits on ionic constituents. However, the water quality standards do contain two provisions which have direct bearing on dissolved materials.

> "The quality of waters shall be such that after treatment consisting of coagulation, settling, filtration, and chlorination, or equivalent treatment processes, the treated water shall meet the bacteriological, physical, and chemical requirements of the latest edition of the United States Public Health Service Drinking Water Standards and any revision or

amendments thereto." "The quality of the water sh..l permit its use for agricultural irrigation without adverse effects or significant damage to any crops or vegetation normally grown in the area."

The treatment processes specified in the requirement for protection of public water supplies do not reduce the concentrations of most ionic constituents in a water supply. Thus, the waters of the Basin must meet the chemical requirements of the PHS Drinking Water Standards. These standards contain two sets of limits on chemical quality. The lower limits, known as desirable criteria, are not to be exceeded unless an alternate source of higher quality water cannot be found. The upper limits are applied to critical parameters and must not be exceeded for the water supply to be acceptable for human consumption.

The Drinking Water Standards specify desirable limits for five parameters of interest in the Souris River Basin: chlorides, sulfates, iron, manganese and total dissolved solids. A limit of 250 mg/l is specified for both chlorides and sulfates. Chloride concentrations exceeding this level impart an undesirable taste. High sulfate concentrations create undesirable tastes and may also produce laxative effects in some people. Desirable limits for iron and manganese are 0.3 and 0.05 mg/l respectively. Concentrations in excess of these limits may cause taste and odors and stain laundry and water fixtures. Total dissolved solids (TDS) concentrations in excess of the desirable limit of 500 mg/l cause essentially the same effects as high concentrations of chlorides or sulphates.

High TDS concentrations also affect irrigation uses. The level of dissolved solids which produces damage to crops is dependent upon a number of factors including type of crop, soil conditions, rainfall, and amount of excess irrigation water applied. In general, TDS concentrations in excess of 500-700 mg/l produce some adverse effects on crop production.

The concentration of sodium in an irrigation water supply relative to the concentrations of other cations (positively charged ions) is also important, as a high ratio of sodium ions may be damaging to irrigation uses even though the TDS concentration is low. Water quality criteria applicable to basin water specify that sodium concentrations shall not exceed 60 percent of total cations measured as milliequivalents per liter.

Average ionic concentrations measured during the July survey are shown in Table VI-5. Chloride concentrations were well below limits and are not significant in this Basin. Sulfate concentrations, however, were much higher (90 to 187 mg/l) and are approaching upper limits for the desirable category. Since concentrations of dissolved solids usually increase during low flow periods, sulfate concentrations may be a problem during those periods. In the Souris River, sulphate concentrations were the lowest in Lake Darling at RM-267.4 (Sta. SR-2) and increased moving downstream, reaching their maximum at RM-108.0 (Sta. SR-7) near Towner. The low sulfate level in Lake Darling

TABLE VI-5

AVERAGE IONIC CONCENTRATIONS

Station	River Mile	Chlorides (Cl) mg/l	Sulfates (SO_4) mg/l	Iron (Fe) mg/l	Manganese (Mn) mg/l	Calcium (Ca) mg/l	Silica (SiO_2) mg/l	Magnesium (Mg) mg/l	Sodium (Na) mg/l	Conductivity Micromohos at 25°C.	Sodium Ratio Percent
					SOURIS RIVER						
SR-1	321.5	40	162	.89	.17	63	13.	26	97	947	44.4
SR-2	267.4	7	90	---	---	--	--	--	--	438	----
SR-3	232.5	12	149	---	---	--	--	--	--	638	----
SR-4	222.1	16	169	---	---	--	--	--	--	735	----
SR-5	197.6	17	161	---	---	--	--	--	--	725	----
SR-6	161.0	18	183	.89	.27	61	12.	27	111	830	47.8
SR-7	108.0	18	187	---	---	--	--	--	--	920	----
SR-8	73.4	21	182	---	---	--	--	--	--	921	----
SR-9	31.8	23	166	---	---	--	10.6	--	--	923	----
SR-10	7.9	15	96	.18	.8	52	8.1	26	67	861	37.9
					TRIBUTARIES						
SC-1	243.7 + 55.6	--	---	---	---	--	--	--	--	239	----
DR-1	243.7 + 48.8	13	173	---	---	--	--	--	--	742	----
DR-2	243.7 + 35.4	--	---	---	---	--	--	--	--	822	----
DR-3	243.7 + 30.2	12	168	.26	.10	61	14.	26	78	836	39.6
MC-1	278.4	--	---	---	---	--	--	--	--	424	----
DC-1	37.3	--	---	---	---	--	--	--	--	923	----

reflects the effect of storing high quality spring runoff. The higher quality releases from this storage are gradually degraded by local runoff and irrigation return flows as the river flows downstream. The two Des Lacs River stations sampled exhibited sulfate concentrations similar to the Souris River below Lake Darling.

Iron concentrations at two of the four stations sampled and manganese at all four stations were above desirable limits. These materials may be released into solution by decaying vegetation. Under anaerobic conditions, they may also be released from bottom sediments. A potential source of these high concentrations would thus be the refuge impoundments.

TDS concentrations were not measured in this survey. For the four stations which had the most ions measured, the sum of the constituent ionic concentrations ranged from 267 to 413 mg/l. Since not all ions were measured, TDS concentrations may be significantly higher. Conductivity readings, which were obtained at all stations, are closely related to TDS concentrations. In many waters, TDS concentrations average about 0.6 of conductivity readings. Applying this factor to observed conductivity readings would indicate that TDS concentrations may presently be as high as 550 mg/l which exceeds desirable limits for public water supply and approaches threshold limits for damage to irrigation uses. TDS concentrations are probably even higher during low flow periods, especially in the lower river below irrigation areas.

Variations in conductivity readings from station to station reflected changes in TDS concentrations similar to those changes observed in sulfate concentrations. Low readings were obtained in Lake Darling (Sta. SR-2) and adjacent Mackobee Coulee (Sta. MC-1) reflecting the high quality water stored from spring runoff and in Stony Run Creek (Sta. SC-1), a high quality tributary of the Des Lacs River. The highest conductivity was recorded on the Souris River at the upper Canadian Border (Sta. SR-1) indicating that the inflow to Lake Darling was of much poorer quality than the stored water. Conductivity progressively increased from Lake Darling all the way downstream to near the border with Manitoba where a slight decrease occurred. Conductivity readings on the Des Lacs River were comparable to those observed in the middle reach of the Souris River.

A comparision of sodium concentrations to other cation concentrations at four stations indicated that sodium is not a hazard to irrigation under present conditions. The ratio of sodium ions to total cations as milliequivalents ranged from 38 to 48 percent.

NITROGEN AND PHOSPHORUS

Algae are dependent for their development upon nutrients dissolved in the water. These nutrients include carbon (C), nitrogen (N), phosphorus (P), and numerous trace elements. High concentrations of nitrogen and phosphorus can stimulate dense algal blooms which produce unaesthetic conditions, taste and odors, diurnal DO variation, and depressed oxygen levels when the blooms die off. Eutrophic waters are characterized by high nutrient concentrations.

In addition to fixation from the atmosphere, sources of nitrogen include municipal and industrial waste effluents, runoff from fertilized farmland, animal and waterfowl wastes, and natural runoff. Nitrogen compounds are removed from surface waters through utilization by aquatic plants, by denitrification and combination with sediments.

The major sources of phosphorus in natural surface waters are weathering of rocks and leaching of soils. Municipal and industrial wastes, waterfowl droppings, and agricultural fertilizers also contribute phosphorus to the aquatic environment. Phosphorus is removed from water bodies by sorption on sediments which settle to the bottom, chemical precipitation and the settling of dead organisms.

Nitrate-nitrogen and phosphorus concentrations were measured in both the Souris and Des Lacs Rivers during the July survey. Souris River levels were also measured again in October. Data are summarized in Table VI-6. Average total phosphorus and nitrate nitrogen (NO_3-N) concentrations for the Souris River for both July and October are plotted against locations in Figure VI-1.

Phosphorus concentrations, both total phosphorus and soluble orthophosphate, were high throughout the basin. Concentrations as shown in Table VI-6, were the highest in July but only slightly lower in October. In the Souris River, phosphorus concentrations were the lowest from the Saskatchewan border through Lake Darling (RM-267.4 to RM-321.5). A large increase in phosphorus levels occurred in the vicinity of Minot (RM-230). A major portion of this increase is due to inflow from the Des Lacs River with the remainder probably due to such factors as agricultural runoff including feedlot wastes, urban runoff and other activities of man in the Minot area. From Minot to the J. Clark Salyer Wildlife Refuge (RM-31.8), total phosphorus concentrations remained relatively constant in July and then decreased in passage through the refuge impoundments. This decrease occurred further upstream in October. In July, an increase in soluble phosphorus occurred in the vicinity of the Velva and Towner waste discharges.

On the Des Lacs River, phosphorus concentrations were high in Upper Des Lacs Lake (Sta. DR-1) and very high near the Kenmare waste discharge in Middle Des Lacs Lake (Sta. DR-2) and a few miles downstream (Sta. DR-3). The Kenmare waste discharge was apparently the source of high phosphorus levels in both the Des Lacs and Souris Rivers. It should be noted that phosphorus levels in the entire system would be relatively high even without this discharge, as shown by concentrations in the Des Lacs River above Kenmare and the Souris River above the mouth of the Des Lacs River. Phosphorus concentrations in Lake Darling and Upper Des Lacs Lake, which are not affected by man-made sources of phosphorus, are adequate to sustain algal blooms.

Nitrate-nitrogen concentrations are usually low (less than 0.1 mg/l) in lakes and other impoundments since conditions for algal and other plant growths are good in such waters and the nitrates may be used by plants as rapidly as they become available. Growth conditions in streams and rivers are less favorable and nitrate nitrogen concentrations are usually higher, ranging between 0.1 and 0.5 mg/l.

NITROGEN AND PHOSPHORUS CONCENTRATIONS FIGURE VI-1

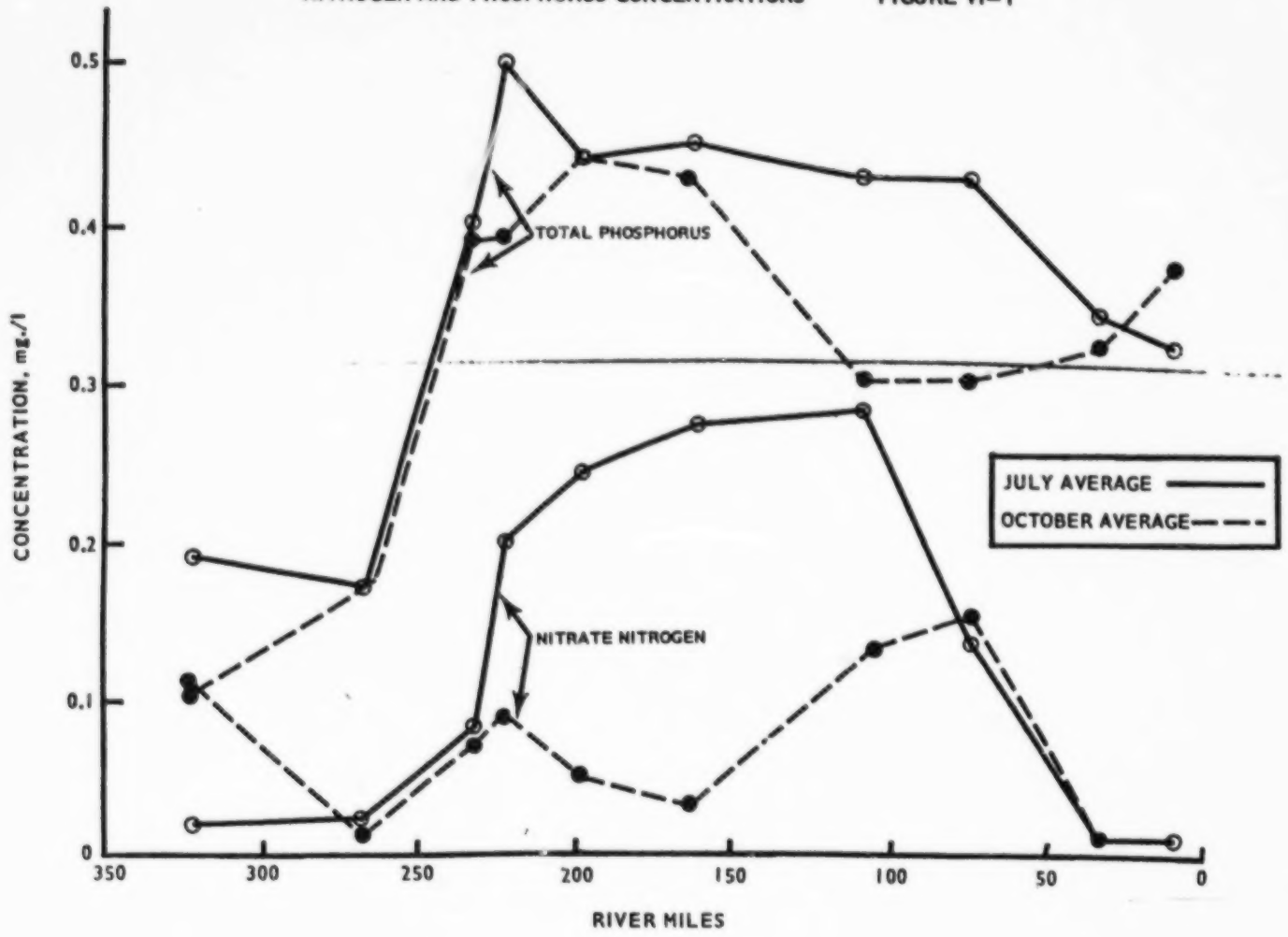


TABLE VI-6

NITROGEN AND PHOSPHORUS

Station	River Mile	Number of Samples	July 7-16, 1969 Total P mg/l			Soluble P mg/l			NO^3-N mg/l			October 1969* Total P mg/l	Soluble P mg/l	NO^3-N mg/l
			Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.			
						SOURIS RIVER								
SR-1	321.5	5	0.25	0.16	0.19	0.17	0.06	0.12	0.04	0.01	0.02	0.10	0.06	0.11
SR-2	267.4	5	0.25	0.12	0.17	0.13	0.11	0.12	0.04	0.01	0.02	0.17	0.07	0.01
SR-3	232.5	4	0.59	0.31	0.40	0.31	0.11	0.22	0.10	0.05	0.08	0.39	0.25	0.07
SR-4	222.1	1	0.50	0.50	0.50	0.28	0.28	0.28	0.20	0.20	0.20	0.39	0.25	0.09
SR-5	197.6	5	0.52	0.37	0.44	0.31	0.23	0.27	0.19	0.19	0.24	0.44	0.24	0.05
SR-6	161.0	5	0.51	0.42	0.45	0.33	0.26	0.31	0.32	0.25	0.27	0.43	0.23	0.03
SR-7	108.0	5	0.52	0.32	0.43	0.39	0.29	0.34	0.38	0.09	0.28	0.30	0.17	0.13
SR-8	73.4	5	0.52	0.37	0.43	0.40	0.32	0.36	0.26	0.02	0.13	0.30	0.17	0.15
SR-9	31.8	5	0.44	0.15	0.34	0.36	0.08	0.34	0.02	0.01	0.01	0.32	0.15	0.01
SR-10	7.9	5	0.36	0.29	0.32	0.30	0.21	0.24	0.01	0.01	0.01	0.37	0.18	0.01
						TRIBUTARIES								
SC-1	243.7 + 55.6	2	0.39	0.35	0.37	0.27	0.25	0.26	0.02	0.02	0.02			
DR-1	243.7 + 48.8	5	0.37	0.23	0.30	0.30	0.16	0.23	0.45	0.35	0.39			
DR-2	243.7 + 35.4	2	0.77	0.62	0.70	0.57	0.54	0.55	0.01	0.01	0.01			
DR-3	243.7 + 30.2	5	1.22	0.50	0.83	1.14	0.37	0.70	0.02	0.01	0.01			
MC-1	278.4	2	0.18	0.14	0.16	0.13	0.07	0.10	0.01	0.01	0.01			
DC-1	37.3	2	0.40	0.18	0.29	0.38	0.06	0.22	0.01	0.01	0.01			

* Single sample at each Souris River Station in October.

In July, nitrate nitrogen concentrations in the Souris River were similar to the typical conditions described above. Average concentrations were less than 0.05 mg/l in Lake Darling and the refuge impoundments. As shown in Figure VI-1, average concentrations were much higher in the free flowing reaches of the river below Minot. These higher nitrogen levels apparently resulted from sources such as urban runoff from Minot, agricultural runoff and feedlot drainage.

In October, nitrate-nitrogen concentrations were similar to July levels in the lakes and impoundments but were much lower in the free flowing reach below Minot. A significant increase in nitrogen levels occurred below the Velva and Towner waste discharges.

Nitrate-nitrogen concentrations were very low in the Des Lacs River and other tributaries sampled in July except for Upper Des Lacs Lake (Sta. DR-1). The average concentration in the lake (0.39 mg/l) was comparable to free flowing conditions on the Souris River and reflected nutrient concentrations capable of supporting an intense bloom. No man caused nutrient sources discharge to this lake.

Average nitrogen and phosphorus loads carried by the Souris River during the July survey period are summarized in Table VI-7. Nitrogen and phosphorus loads at key points on the river are also shown in Figure VI-2. Since average stream flow was relatively constant in the entire river below the mouth of the Des Lacs River, these loads vary directly with concentrations.

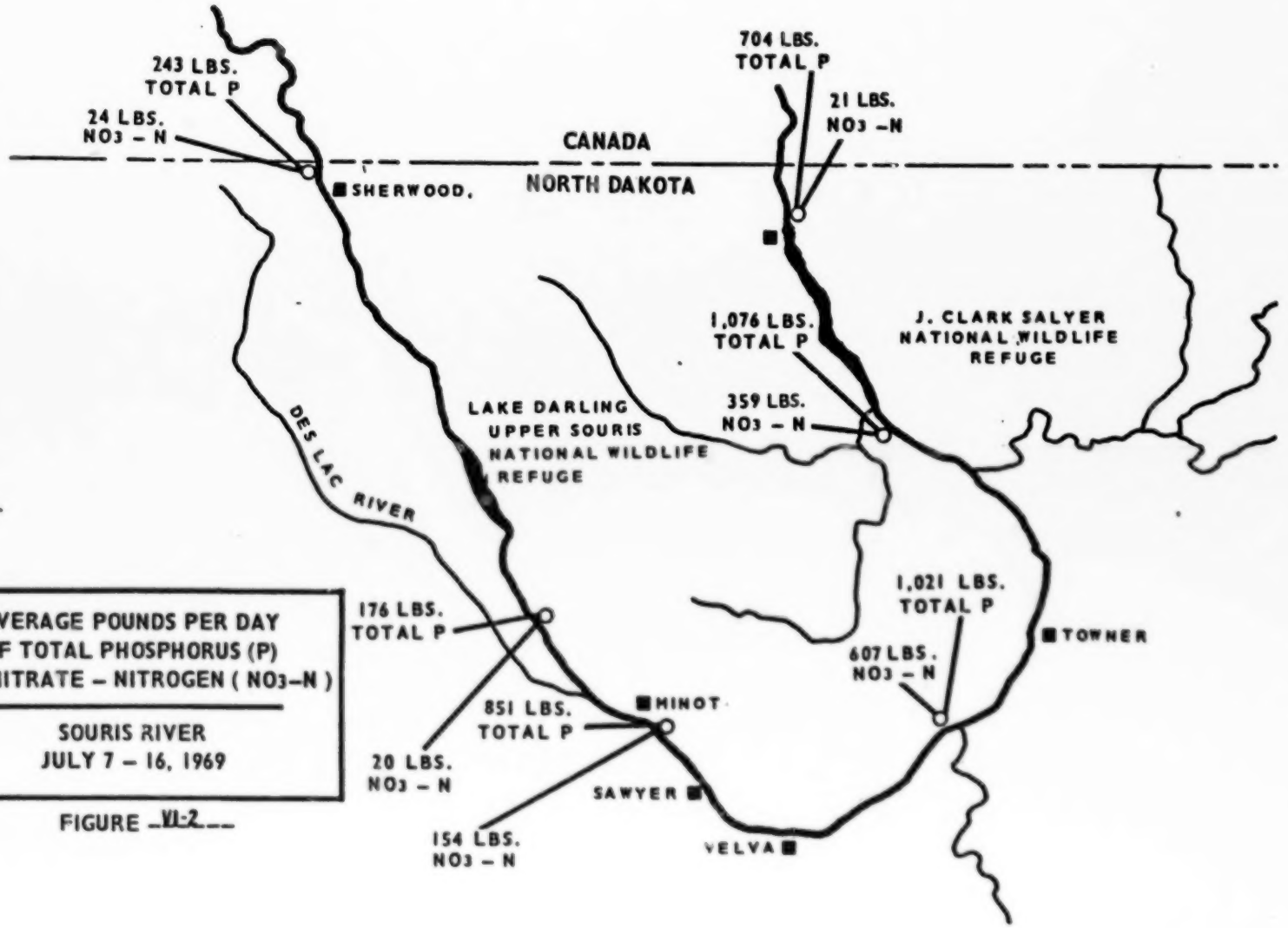
TABLE VI-7

AVERAGE NITROGEN AND PHOSPHORUS

Station Number	River Mile	Flow* MGD	NUTRIENTS Total P*		Soluble P*		NO_3-N*	
			mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day
SR-1	321.5	152	0.19	243	0.12	152	0.02	24
SR-2	267.4	126	0.17	176	0.12	126	0.02	20
SR-3	232.5	258	0.40	851	0.22	464	0.08	154
SR-6	161.0	276	0.45	1,021	0.31	717	0.27	607
SR-8	73.4	299	0.43	1,076	0.36	897	0.13	359
SR-10	7.9	261	0.32	704	0.24	495	0.01	21

* All values are averages for sampling period July 7-16, 1969.

Waters of the Souris River system are heavily enriched with nutrients. Intense blooms of algae and other eutrophic conditions are present in the system. Waste sources contribute substantial loads of nitrogen and phosphorus to the river. A detailed nutrient balance is needed to measure the effects of the waste sources.



AVERAGE POUNDS PER DAY
OF TOTAL PHOSPHORUS (P)
AND NITRATE – NITROGEN (NO3–N)

SOURIS RIVER
JULY 7 – 16, 1969

FIGURE VI-2

BACTERIAL CONCENTRATIONS

Bacteria of the coliform group have been widely used as indicators of water pollution originating from the excreta of warm-blooded animals including man, and domestic and wild birds and mammals. Concentrations of coliform bacteria exceeding specified limits which vary by type of water use are considered to be indicators that pollution exists which poses a health hazard for that water use. Since some types of coliform bacteria originate from soil sources, high total coliform counts may be measured under certain conditions without a known source of fecal contamination. For this reason, measurement of fecal coliform concentrations provides a more positive index of the degree of pollution present. The presence of significant concentrations of fecal coliform organisms is considered positive evidence of recent fecal contamination.

Water quality criteria established by the State of North Dakota for the Souris and Des Lacs Rivers, based on total coliform concentrations, are as follows:

> "Coliform organisms - the average arithmetical monthly (MPN) shall not exceed 1,000/100 ml in the Lake Darling Reservoir. The average arithmetical monthly (MPN) shall not exceed 3,000/100 ml in the stream or in an MPN exceeding this number in more than 20% of the samples collected during any one month, or in a MPN exceeding 7,500 in more than 5% of such samples per month."(2)

These criteria are designed to protect the waters of the Souris and Des Lacs Rivers for municipal and industrial water supply, recreation, fishing, wildlife and agricultural uses.

During the July water quality survey, both total coliform and fecal coliform concentrations were determined at each sampling station. Bacteriological data are summarized in Table VI-8. Observed concentrations, potential sources of bacteriological pollution and compliance with applicable criteria are discussed in the following paragraphs.

In Lake Darling (Sta. SR-2) total coliform densities were less than the North Dakota Water Quality Standard. Fecal coliform densities were also less than the suggested limit for primary contact recreation. Similar low concentrations of both total and fecal coliform bacteria were observed in other basin impoundments except for Middle Des Lacs Lake (Sta. DR-2) which receives the untreated Kenmare municipal wastes. However, total coliform densities in Middle Des Lacs Lake met the applicable water quality criterion and fecal coliform densities were below the suggested limit for secondary contact recreation.

Total coliform concentrations were in violation of applicable water quality criteria at three locations on the Souris River. At RM-222.1 (Sta. SR-4) and RM-197.6 (Sta. SR-5), average total coliform concentrations were well above the assigned 3,000 per 100 ml limit. These two locations are affected by urban runoff from the Minot area. The third location was at RM-73.4 (Sta. SR-8) which is about 28 miles downstream from the Towner waste discharge. Observed total coliform

TABLE VI-8

BACTERIOLOGICAL DATA

Station	River Mile	Number of Samples	TOTAL COLIFORM/100 ml.			FECAL COLIFORM/100 ml.		
			Maximum	Minimum	Average	Maximum	Minimum	Average
				SOURIS RIVER				
SR-1	321.5	10	600	30	147	130	1	29
SR-2	267.4	10	500	30	166	50	1	19
SR-3	232.5	8	3,500	400	1,208	1,600	70	346
SR-4	222.1	2	8,300	2,500	5,400	900	270	585
SR-5	197.6	10	68,000	1,100	9,630	1,000	1	311
SR-6	161.0	10	3,200	1,300	2,100	860	100	315
SR-7	108.8	10	1,900	260	637	300	1	103
SR-8	73.4	10	1,500,000	7,500	378,350	1,300	90	530
SR-9	31.8	9	8,400	70	1,200	5,000	1	618
SR-10	7.9	10	700	100	299	70	1	23
				TRIBUTARIES				
SC-1	243.7 + 55.6	5	100	5	38	1	1	1
DR-1	243.7 + 48.8	10	500	1	98	---	---	---
DR-2	243.7 + 35.4	5	4,000	200	1,560	600	20	148
DR-3	243.7 + 30.2	10	2,000	30	628	300	20	68
MC-1	278.4	5	1,600	15	389	75	5	36
DC-1	37.3	5	2,200	100	860	230	30	113
				WASTE EFFLUENTS				
Velva	185.0	4	53,000,000	2,000,000	21,925,000	3,600,000	430,000	2,007,000
Towner	101.0	5	73,000,000	17,000,000	33,800,000	8,600,000	640,000	3,920,000

concentrations at this location, ranged from 7,500 to 1,500,000 per 100 ml with an average of 378,350 per 100 ml, were the highest for any Basin location sampled. These high concentrations were apparently the result of bacterial regrowth in the river, stimulated by nutrients in cheese wastes discharged at Towner.

Except for the location affected by the Towner waste discharge, all of the high total coliform concentrations observed were attributable to sources of pollution which are not readily controllable. Even though violations of total coliform standards occurred, fecal coliform concentrations were below recommended limits at all locations sampled. This fact would indicate that the bacterial quality of Basin waters, except in the immediate vicinity of inadequately treated waste discharges, was suitable for designated uses. A fecal coliform criterion would thus appear to be more realistic than the existing total coliform criterion in the Souris River Basin.

OTHER PARAMETERS

Water temperature, pH and turbidity were measured at all sampling stations. Average values for these data were previously summarized in Table VI-1 in the section on dissolved oxygen.

Average water temperatures measured during the July 7-16, 1969, survey period ranged from 18.5 to 21.0°C. These temperature readings were taken during the morning hours so were lower than daily maximum temperatures. Slightly higher water temperatures were measured by the water quality monitors which were operated one week later than the main survey. Monitor data (see Table VI-3) reflected a "typical" duirnal temperature fluctuation pattern. Maximum temperatures measured by both the regular survey and the monitor were less than the maximum temperature limit of 90°F (32°C) specified in the water quality standards. There are no significant sources of thermal pollution in the Basin.

The water quality criteria specify that pH must range between 7.0 to 9.0. Values of pH ranged from 7.5 to 8.6, well within the specified range. Surface waters in this area are slightly alkaline, as demonstrated by the pH values consistently greater than 7.0.

Observed turbidity readings were typical of the types of water bodies present in the basin. Turbidity readings were relatively low (3 to 10 Jackson turbidity units) in the lakes and impoundments. In the free flowing streams, turbidity was significantly higher, ranging from 18 to 50 Jackson turbidity units. This higher turbidity was the result of such factors as urban and rural runoff carrying sediments into the streams, coupled with stream turbulence which tends to keep materials in suspension. Turbidity readings in the range observed in the stream reaches reduce the desirability of the stream as a source of public water supply. However, this level of turbidity is common in many waters used as public water supplies and can readily be removed by standard treatment practices. No numerical limits on turbidity are specified in the North Dakota Water Quality Standards.

CHAPTER VII. BIOLOGICAL EVALUATIONS

A. BIOLOGICAL INDICATORS OF WATER QUALITY

Water quality conditions determine the composition of aquatic biota. Therefore, the types and numbers of aquatic organisms present in a water body are good indicators of water quality. Clean water is usually characterized by small numbers of organisms and a wide variety of species. In contrast, polluted water bodies frequently support large numbers of organisms but only a few tolerant species. In cases of severe water quality degradation, all aquatic life may be eliminated.

Benthos and phytoplankton are frequently utilized as biological indicators of water quality. Bottom associated organisms (benthos) have limited mobility and relatively long life spans. For these reasons, benthos are indicators of past as well as present water quality. Different kinds of benthic organisms have different levels of tolerance to pollution and water quality degradation. An absence of pollution sensitive forms and an abundance of tolerant forms indicates that poor water quality has existed in the area at least part of the time.

Phytoplankton (suspended algae) also are responsive to water quality conditions. The relative abundance of algae can be an indication of levels of available nutrients in the water. Algal growth rates are also influenced by such factors as light penetration and the presence or absence of moving water. The relative magnitude of algal numbers thus must be evaluated in relation to all of these factors. The types of algae which predominate are also an indication of water quality. For example, many types of green algae inhabit only relatively clean water, whereas some blue-green algae thrive in water degraded by organic pollution.

The chemical composition of benthic sediments is related to and exerts an important influence on the quality of overlying waters. Sediments which contain large amounts of organic carbon and nitrogen resulting from eutrophication or the discharge of organic wastes containing settleable wastes to the overlying waters will exert a high oxygen demand while undergoing decomposition. This demand can deplete dissolved oxygen levels in overlying waters with adverse effects on water uses and aquatic biota. Sediments can also act as reservoirs for recycling of nutrients into the overlying waters. Examination of the sediments gives an indication of the history of overlying water quality conditions.

B. BENTHOS

Samples of bottom associated organisms collected from a total of twenty-two biological stations on the Souris River and eight stations on the Des Lacs River during the June survey were evaluated. These same stations were again sampled for benthos in October with four additional sampling stations being added on the Souris River. Both the areal density and genera of benthos were evaluated at each stations. The benthos throughout much of the Souris and Des Lacs River Basins were indicative of moderate eutrophication. Organisms associated with high levels of organic and inorganic nutrients

were collected in abundant numbers at practically all stations.

Souris River

Benthos collected at Souris River stations in June 1969 are listed in Table VII-1. Benthos collected in October 1969 are summarized in Table VII-2. Interpretations of the significance of the various kinds and numbers of benthos observed at each station are presented in downstream order in the following paragraphs.

The farthest upstream stations, River Mile RM-358.2 (Sta. USC-1) near North Portal, Saskatchewan, and RM-353.5 (Sta. US-1) a short distance downstream from the Canadian border, representative pollution sensitive organisms were collected which indicated clean water areas free from significant man-made pollution. Downstream at RM-326.7 (Sta. US-3) and RM-320.5 (Sta. US-4), the numbers and kinds of pollution sensitive forms decreased. The pollution sensitive forms were completely eliminated at RM-320.5 in October. This stretch of the river (Mouse River Park) is heavily populated with summer residences. Practically all of the houses observed along either bank had their sanitation facilities located on the edge of the river, or in the case of several homes, the "privy" was on a stationary dock extending into the river. Benthos in this section of the Mouse River Park reflected degraded water quality.

The Upper Souris National Wildife Refuge extends from about RM-270 to about RM-330 and includes all of Lake Darling as well as other marshes and impoundments in this reach. At RM-305.8 (Sta. LD-1) and RM-278.4 (Sta. LD-3), in Lake Darling, the organisms sampled were characteristic of clean water, indicating that water quality had recovered from the degradation noted upstream in the Mouse River Park Area. The abundance of benthos, particularly during the October survey (3,434 organisms per sq. ft.) reflects the inflow and deposition of large amounts of organic materials into the Lake. Immediately downstream from the Lake Darling outflow structure at RM-275.3 (Sta. 5-1), large quantities of pollution sensitive mayflies and caddisfly larvae were collected. Also included in the benthos at this point were large densities of intermediate and pollution tolerant forms indicative of an enriched organic environment.

In the reach between Lake Darling and Minot, North Dakota (about RM-230), the benthos were not present in as large numbers as at upstream stations. Pollution sensitive organisms were present at all stations (S-1 to S-4) during both the June and October surveys indicating this reach has moderate to good water quality. The number of pollution sensitive forms decreased sharply at RM-228.9 (Sta. S-6) in the vicinity of Minot during the October survey and were completely absent in June. The lack of pollution sensitive forms during June was indicative of poor water quality. The collections in October reflected poor to moderate water quality. The river flows through Minot receiving pollution from private homes and businesses located along the banks. During both surveys, floating oil and oil

TABLE VII–I

BOTTOM ASSOCIATED ORGANISMS, BOISE RIVER

SOUTH DAKOTA AND CANADA

June, 1969

(Number per square foot)

RIVER MILE / STATION NUMBER	350.5 35-1	353.9 35-1	356.7 35-2	359.5 35-4	369.0 36-1	395.6 36-1	376.4 36-3	375.3 8-1	367.6 8-1	363.5 8-4	359.0 8-5	327.1 8-9	325.6 8-13	321.0 8-15	300.0 8-17	301.9 8-18	301.5 8-19	98.7 8-20	80.1 8-21	73.4 8-23	63.9 8-24	63.4 8-28	31.6 8-36	7.9 8-37	1.9 8-42	0.0 8-46
ORGANISM																										
PERMITTED ORGANISMS																										
COLEOPTERA																										
Simulia	-	-	-	-	-	-	-	-	-	-	-	-	-	NS	-	-	-	NS	-	NS	4	-	-	NS	-	
Stenelmis	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
EPHEMEROPTERA																										
Baetis	-	0	0	-	-	-	-	-	-	-	-	0	0		-	-	-		-		-	-	-		-	
Caenis	-	-	-	-	-	4	3	32	0	-	-	0	3		-	-	-		13		0	0	4		4	
Heptagenia	-	0	-	-	-	-	-	-	-	-	-	-	0		-	-	-		0		-	-	-		-	
Leptagenia	-	-	-	-	8	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Stenonema	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
PLECOPTERA																										
Perlesta	-	-	0	-	-	-	-	-	-	-	-	-	0		-	-	-		-		-	-	-		-	
TRICOPTERA																										
Athripsodes	-	-	-	-	-	-	-	-	-	0	-	-	-		-	-	-		-		-	-	-		-	
Cheumatopsyche	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Hydropsyche	-	-	-	-	-	-	-	-	0	-	-	-	-		-	-	-		-		-	-	-		-	
Limnephilus	0	-	-	-	-	-	-	-	0	-	-	-	0		-	-	0		0		-	0	-		-	
Molanna	-	-	-	-	-	-	-	0	-	0	-	-	-		-	-	-		-		-	-	-		-	
Neophylax	-	0	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Nectopsyche	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Oecetis	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Polycentropus	-	0	0	-	-	-	-	0	-	0	-	-	0	0		1	-	0		-		-	-	0		-	
SUBTOTAL	3	4	3	8	0	4	3	34	3	3	8	0	3	7		2	0	2		14		5	3	5		4
SUBTOTAL KINDS	3	4	3	8	0	1	1	3	3	3	8	0	3	6		1	0	2		3		2	2	3		1
INTERMEDIATE ORGANISMS																										
COLEOPTERA																										
Dineutus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		0	
Dytiscus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Dytinus	-	-	-	-	-	-	-	0	-	-	-	-	-		-	-	-		-		-	-	-		-	
Haliplus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Hydaticus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Hydrocanthus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Hydroporus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	0	0		-	
Hydrophilus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Laccodytes	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	0		-		-	-	-		-	
Peltodytes	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
CRUSTACEA																										
Gammarus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		0	-	32		-	
Hyalella azteca	0	-	-	-	-	0	0	10	0	0	0	0	0	0		4	-	4		8		24	12	96		0	
Orconectes virilis	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		-	-	-		-	
DIPTERA																										
Chaoborus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		0		-	-	-		-	
Chironomus (Cryptochironomus)	2	-	-	-	-	-	43	16	-	-	-	-	-		-	-	0		0		-	40	16		4	
C. (Dicrotendipes)	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	16		44		4	4	0		-	
C. (Endochironomus)	-	2	-	-	-	-	-	-	-	-	-	-	-		-	-	-		0		-	-	-		-	
Cladotanytarsus	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Cricotopus	-	-	-	-	15	-	48	-	-	-	-	-	-		-	-	-		0		0	0	-		20	
Cryptotendipes	6	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Dasyhelea	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Glyptotendipes	-	-	-	-	-	-	-	-	-	-	-	-	-		0	-	-		4		-	-	-		-	
Heterotrissocladius	-	-	-	-	32	-	64	-	-	-	-	-	-		-	-	4		-		8	-	8		12	
Polypedilum Nubifolia	8	0	4	-	-	16	64	32	-	-	-	-	2		-	-	-		-		4	-	-		4	
Polypedilum	0	4	-	-	496	-	-	16	16	-	-	-	0	20		2	-	-		-		4	12	48		8	
Procladius	20	-	-	-	80	-	48	16	16	0	-	-	-			-	-	-		-		-	12	64		-	
Psectrocladius	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		-	-	-		-	
Paracricotopus	-	0	-	-	-	-	-	-	-	-	-	-	0			-	-	-		-		-	-	-		-	
Pseudochironomus	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		-	-	-		-	
Simulium	0	4	32	-	-	-	-	-	16	0	-	-	0	0		-	-	2		-		-	-	-		-	
Tanytarsus	4	8	-	-	16	-	32	64	-	-	-	0	0			-	-	8		16		-	-	-		-	
Tanypus	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		-	-	16		-	
GASTROPODA																										
Aplexa	-	-	-	-	-	0	-	-	-	-	-	-	-			-	-	-		-		-	-	-			
Parvinsia	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		-	-	-			
Pseudosuccinea	-	-	-	-	-	0	-	-	-	-	-	-	-			-	-	-		-		-	-	-			
Gyraulus	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		0	16	32			
Helisoma	-	-	-	-	-	0	-	-	-	-	-	-	40			-	-	-		-		-	-	-			
Lioplax	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		-	-	-			
Lymnaea	-	-	-	-	-	-	-	-	-	-	-	0	456			-	-	0		20		72	4	32			
Lymnaea	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		-		-	-	-			
Paludestrina	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		4		-	-	-			
Promenetus	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-		0		-	-	32		0	
Pseudosuccinea	-	-	-	-	-	0	-	-	-	-	-	-	88			-	-	-		-		4	-	4		-	
Valvata	4	-	8	12	-	-	-	-	-	-	-	-	-			-	-	-		-		12	16	4		40	
HEMIPTERA																										
Gerridae	-	-	-	-	-	0	-	-	-	-	-	-	-	-		0	-	0		0		1	-	-		0	
HIRUDINEA																										
Argia	-	-	-	-	-	-	-	-	-	-	-	0	-	-		-	-	-		4		-	-	-		-	
Erpobdella	-	-	-	-	-	0	-	-	-	-	-	-	-	-		0	-	-		0		-	-	0		-	
Notoerina	-	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Ischnura	-	-	-	-	-	0	-	-	0	-	0	-	-	-		-	-	-		-		-	-	-		-	
PELYCYPODA																										
Alasmidonta	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-		-	-	-		-	
Amblema	-	-	-	-	-	-	-	-	-	-	-	-	32	-		-	-	-		-		-	-	-		-	
Dupera	-	-	-	-	0	-	-	-	-	-	-	-	-	-		-	-	-		-		-	0	-		-	
Lampsilis	-	-	-	-	-	-	-	0	-	-	-	-	-	2		2	-	-		-		-	-	-		-	
Musculium	2	24	16	16	-	-	16	176	48	-	-	-	-	-		-	-	-		-		-	4	-		96	
Pisidium	-	-	-	-	-	-	560	320	-	0	-	0	216	-		-	-	-		-		4	-	-		-	
Sphaerium	-	32	4	4	-	-	-	-	32	-	-	-	56	-		-	-	-		72		4	-	-		-	
SUBTOTAL	43	89	64	32	640	64	859	885	155	4	1	5	958	24		11	0	43		198		144	122	387		173	
SUBTOTAL KINDS	9	10	5	3	7	9	9	9	8	4	1	5	11	5		4	0	9		14		14	11	13		11	
TOLERANT ORGANISMS																										
DIPTERA																										
Chironomus	4	-	-	-	16	-	48	-	-	-	-	-	-	-		-	-	4		-		4	44	16		-	
C. (Riefenia)	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		24		0	-	-		0	
Culicidae	-	-	4	4	16	32	-	-	-	-	-	-	-	-		-	-	4		0		0	-	-		0	
GASTROPODA																										
Physa	0	30	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		8		0	4	20		-	
HIRUDINEA	4	-	-	-	-	-	-	0	-	-	-	2	0	-		0	-	-		24		4	-	264		-	
OLIGOCHAETA																										
Lumbriculidae	-	-	4	-	80	-	-	-	-	-	-	-	-	-		2	-	-		76		0	-	-		-	
Naididae	-	-	-	-	-	-	-	-	-	-	0	-	-	-		-	-	0		-		-	-	-		-	
Tubificidae	248	4	-	-	-	16	-	-	-	-	4	0	-	-		-	-	-		12		24	4	112		-	
SUBTOTAL	257	34	8	4	112	48	48	1	0	0	4	4	1	0		3	0	10		157		36	52	412		2	
SUBTOTAL KINDS	4	3	2	1	3	2	1	1	0	0	1	1	1	0		2	0	3		5		3	3	3		1	
GRAND TOTAL NO. PT.	345	127	76	44	752	116	907	920	158	7	13	11	972	31		16	0	55		369		185	174	802		175	
NUMBER OF KINDS	16	18	12	5	8	12	11	13	11	7	3	8	13	11		9	0	14		23		23	19	21		14	

Q=Organisms not collected quantitatively, arbitrarily given value of one for computing
NS=Not sampled

TABLE VII–2

BENTHOS ASSOCIATED ORGANISMS, SNAKE RIVER

SOUTH DAKOTA AND IOWA

OCTOBER, 1969

(Number per square foot)

| RIVER MILE / STATION NUMBER | 340.2 SC-1 | 333.3 SD-1 | 326.7 SD-2 | 320.5 SD-3 | 305.0 SD-4 | 295.6 SD-5 | 278.4 SD-6 | 275.3 SD-7 | 267.4 SD-8 | 263.5 SD-9 | 259.9 SD-10 | 253.1 SD-11 | 248.6 SD-12 | 241.9 SD-13 | 240.7 SD-14 | 237.1 SD-15 | 233.4 SD-16 | 228.4 SD-17 | 223.4 SD-18 | 218.4 SD-19 | 213.4 SD-20 | 208.4 SD-21 | 203.4 SD-22 | 198.4 SD-23 | 193.4 SD-24 | 188.4 SD-25 | 183.4 SD-26 | 178.4 SD-27 | 173.4 SD-28 | 168.4 SD-29 | 163.4 SD-30 | 158.4 SD-31 | 153.4 SD-32 | 148.4 SD-33 | 143.4 SD-34 | 138.4 SD-35 | 133.4 SD-36 | 128.4 SD-37 | 123.4 SD-38 | 118.4 SD-39 | 113.4 SD-40 | 108.4 SD-41 | 103.4 SD-42 | 98.4 SD-43 | 93.4 SD-44 | 88.4 SD-45 | 83.4 SD-46 | 78.4 SD-47 | 73.4 SD-48 | 68.4 SD-49 | 63.4 SD-50 | 58.4 SD-51 | 53.4 SD-52 | 48.4 SD-53 | 43.4 SD-54 | 38.4 SD-55 | 33.4 SD-56 | 28.4 SD-57 | 23.4 SD-58 | 18.4 SD-59 | 13.4 SD-60 | 8.4 SD-61 | 3.4 SD-62 |
|---|---|---

in the sediments were noted in this reach of the river. One source of oil observed was a service station situated on the river's edge.

In a 3/4 mile reach immediately downstream from the Minot water treatment plant at about RM-230, the bottom sediments were comprised primarily of lime sludge discharged by the treatment plant. In this area of sludge deposition, most bottom associated organisms were eliminated. However, all traces of the lime sludge had disappeared at RM-228.9 (Sta. S-6).

Immediately downstream from Minot at RM-222.1 (Sta. S-9 at the U. S. Highway 2 Bypass), the benthos collected during the October survey evidenced a recovery in water quality, but pollution tolerant sludgeworms still predominated in the collections. Small numbers of sensitive mayflies and caddisfly larvae were observed in this area.

Between Minot (RM-243.5) and Towner (RM-101.5), the Souris River displayed improved conditions supporting an abundance of pollution sensitive benthos. The burrowing mayfly Hexagenia sp., which is quite sensitive to low dissolved oxygen levels and toxic wastes, was encountered in large numbers at RM-161.0 (Sta. S-15) near Verendrye. At the time of the survey, the town of Velva was discharging untreated domestic wastes to the river at RM-185.0. The benthos collected at RM-161.0 thus indicated recovery of water quality in the reach between Velva and Verendrye.

The most degraded water quality conditions encountered during the biological surveys were observed at RM-101.5 (Sta. S-19) about 100 yards downstream from the sewage outfall at Towner, North Dakota. Industrial wastes from a cheese factory and domestic wastes from the community were being discharged to the river without treatment at the time of the surveys. Virtually all forms of benthic organisms were eliminated in this reach of the river. Human feces and cheese whey from the factory were observed floating on the water surface. Bottom sediments emitted hydrogen sulfide odors which indicated septic conditions. Extensive growths of the sewage slime Sphaerotilus natans, apparently stimulated by cheese factory wastes, were observed clinging to submerged objects from near the outfall to a point approximately five miles downstream.

Only small numbers of two kinds of pollution sensitive caddisflies larvae and no mayflies were observed in benthos samples obtained in June at RM-98.7 (Sta. S-20) about three miles downstream from the Towner outfall. October benthos samples contained only small numbers of intermediate and pollution tolerant forms. Pollution sensitive benthos were not observed in downstream samples until RM-78.4 (Sta. S-23) near Bantry about 23 miles downstream from the Towner outfall. It was apparent that the untreated domestic and industrial wastes discharged at Towner degraded water quality in the Souris River for many miles.

The lower 80 miles of the United States portion of the Souris River are located in the J. Clark Salyer Wildlife Refuge (also known as the Lower Souris National Wildlife Refuge). This reach is characterized by numerous shallow impoundments and marsh areas. In the upstream reach of the Refuge

from RM-78.4 to RM-42.4 (Stas. S-23 to S-28), benthos samples contained moderate to high numbers of intermediate and pollution tolerant organisms; whereas in the lower portion of the Refuge between RM-21.6 and RM-0.0 at the Canadian border (Stas. S-34 to S-41c), samples had moderate numbers of pollution tolerant organisms and moderate numbers of pollution sensitive kinds, particularly the mayfly Caenis sp. This organism, though tolerant to low dissolved oxygen concentrations, is considered sensitive to septic conditions.

At RM-0.0 (Sta. S-41c) near Coulter, Manitoba, low numbers of all kind of organisms were collected during the June and October surveys. The October survey reflected moderate to poor water quality. This condition was attributed to depression in the dissolved oxygen levels by decomposition of a large bloom (54,120 cells/ml) of algae.

Des Lacs River Stations

Benthic samples collected from Des Lacs River stations, like the Souris River samples, contained numbers and kinds of bottom associated organisms characteristic of eutrophic waters. The limited numbers of benthos collected also suggested periods of no flow. The numbers and kinds of benthos collected from the Des Lacs River stations in June and October, 1969, are summarized in Tables VII-3 and VII-4 respectively.

The upper 30 miles of the Des Lacs River in the United States, extending downstream from the Canadian border to below Kenmare, North Dakota, are located in the Des Lacs National Wildlife Refuge. Almost the entire reach consisted of shallow impoundments and marshes. Upper Des Lacs Lake extending north from Kenmare (about RM-35), Middle Des Lacs Lake at Kenmare, and Lower Des Lacs Lake extending downstream from Kenmare to about RM-30 are the major impoundments. Samples obtained from the various stations located in the impoundments (Stas. DL-1 to DL-5) contained benthos indicative of water exhibiting low dissolved oxygen concentrations over extended periods of time. Benthos collected from Middle Des Lacs Lake 100 yards offshore from the Kenmare sewage outfall at RM-35.0 (Sta. DL-4A) reflected severe degradation of the bottom sediments. Discharge of municipal wastes from Kenmare without treatment has degraded water quality and limited the benthos to pollution intermediate and tolerant forms. Sediments from this area contained visible amounts of oil and emitted odors associated with septicity.

At RM-29.5 (Sta. DL-8), below Lower Des Lacs Lake and more than five miles downstream from the Kenmare outfall, benthos samples still reflected poor water quality. During both the June and October surveys, accumulations of foam below an irrigation dam was noted.

Pollution sensitive organisms were observed at RM-24.5 and at RM-1.5 (Stas. DL-11 and DL-17) near the confluence with the Souris River. These organisms indicated that water quality in this reach had recovered sufficiently to support sensitive organisms throughout the year. An upstream irrigation

TABLE VII-3

BOTTOM ASSOCIATED ORGANISMS, DES LACS RIVER

NORTH DAKOTA

June, 1969

(Number per square foot)

ORGANISM	RIVER MILE STATION NUMBER	343.7, 40.3* DL-1	343.7, 36.2 DL-3	343.7, 35.0* DL-4a	343.7, 34.9 DL-4b	343.7, 34.0 DL-5	343.7, 29.5* DL-8	343.7, 24.5* DL-11	343.7, 1.5 DL-17
SENSITIVE ORGANISMS									
EPHEMEROPTERA									
Baetis		-	-	-	-	-	-	-	-
Caenis		-	-	-	-	-	-	Q	Q
Stenonema		-	-	-	-	-	-	-	-
TRICOPTERA									
Cheumatopsyche		-	-	-	-	-	-	-	-
Limnephilus		-	4	-	-	-	-	-	-
Nuophylax		-	-	-	-	-	-	-	-
Rhyacophilidae		-	-	-	-	-	-	-	-
SUBTOTAL		0	4	0	0	0	0	1	1
SUBTOTAL KINDS		0	1	0	0	0	0	1	1
INTERMEDIATE ORGANISMS									
COLEOPTERA									
Hydroporus		2	4	-	-	-	-	-	1
Laccophilus		-	-	-	-	-	-	-	-
CRUSTACEA									
Gammarus		-	-	-	-	Q	-	-	-
Hyalella azteca		10	4	4	7	7	3	Q	Q
DIPTERA									
Chironomus (Cryptochironomus)		-	-	4	-	1	-	-	1
C. (Dicrotendipes)		-	-	-	-	-	1	-	-
C. (Endochironomus)		-	-	-	-	-	-	-	-
Cricotopus		4	-	-	-	Q	11	Q	-
Glyptotendipes		-	-	-	-	-	-	-	-
Goeldichironomus holoprasinus		-	-	-	-	-	-	-	-
Harnischia		-	4	-	-	2	4	-	-
Palpomyia tibialis		-	-	4	-	-	-	-	-
Polypedilum		2	-	-	1	-	-	-	-
Probezzia		-	-	-	-	Q	-	-	-
Procladius		-	-	88	6	-	-	-	-
Pseudochironomus		-	-	-	-	-	-	-	-
Simulium		-	-	-	-	-	12	-	-
Tanypus		-	4	-	-	-	-	-	-
Tanytarsus		-	-	-	-	-	-	-	-
GASTROPODA									
Aplexa		-	-	-	-	-	-	-	-
Fossaria		-	-	-	-	-	-	-	-
Gyraulus		-	8	4	-	-	-	-	-
Helisoma		-	-	-	-	-	-	-	-
Lymnaea		-	-	-	-	1	-	-	-
Promenetus		-	-	-	-	-	-	-	-
Pseudosuccinea		-	-	-	-	-	-	-	-
HEMIPTERA									
Corixidae		-	-	-	-	-	-	-	-
ODONATA									
Argia		-	-	-	-	-	-	-	-
Gomphus		-	-	-	-	-	-	-	-
PELYCYPODA									
Musculium		-	-	-	-	-	-	-	-
Pisidium		-	-	-	-	-	-	-	-
Sphaerium		-	-	-	-	-	-	-	-
SUBTOTAL		18	24	104	14	14	31	2	3
SUBTOTAL KINDS		4	5	5	3	5	5	2	3
TOLERANT ORGANISMS									
DIPTERA									
Chironomus		52	24	148	-	-	-	-	6
C. (Xinfeldia)		-	-	-	-	-	-	-	-
C. (Klefferulus)		-	68	-	-	-	-	-	-
Culicidae		-	-	4	-	-	3	-	-
GASTROPODA									
Physa		-	-	16	-	-	-	Q	Q
HIRUDINEA		3	-	-	1	-	-	-	-
OLIGOCHAETA									
Lumbriculidae		-	-	-	-	-	-	-	-
Naididae		-	-	-	-	-	-	-	1
Tubificidae		-	4	4	-	6	46	1	3
SUBTOTAL		55	96	172	1	6	49	2	11
SUBTOTAL KINDS		2	3	4	1	1	2	2	4
GRAND TOTAL/SQ. FT.		73	124	276	15	20	80	5	15
NUMBER OF KINDS		6	9	9	4	8	7	5	8

Q=Organisms not collected quantitatively, arbitrarily given value of one for computing
NS=Not sampled

TABLE VII-4

BOTTOM ASSOCIATED ORGANISMS, DES LACS RIVER

NORTH DAKOTA

October, 1969

(Number per square foot)

ORGANISM	RIVER MILE / STATION NUMBER	343.7, 40.3 B1c-1	343.7, 36.3 B1c-2	343.7, 35.8 B1c-3a	343.7, 34.5 B1c-4b	343.7, 34.0 B1c-5	343.7, 29.5 B1c-8	343.7, 26.9 B1c-11	343.7, 1.9 B1c-17
SENSITIVE ORGANISMS									
EPHEMEROPTERA									
Baetis		-	16	-	-	-	-	Q	-
Caenis		-	-	-	-	-	-	-	-
Stenonema		-	-	-	-	-	-	Q	-
TRICOPTERA									
Cheumatopsyche		-	-	-	-	-	-	-	Q
Limnephilus		-	-	-	-	-	-	-	-
Neophylax		-	-	-	-	-	-	Q	-
Rhyacophilidae		-	-	-	-	4	-	-	-
SUBTOTAL		0	16	0	0	4	0	3	1
SUBTOTAL KINDS		0	1	0	0	1	0	1	1
INTERMEDIATE ORGANISMS									
COLEOPTERA									
Hydroporus		-	-	-	-	-	-	Q	-
Laccophilus		-	Q	-	-	-	-	-	-
CRUSTACEA									
Gammarus		-	-	-	-	-	-	Q	-
Hyalella azteca		40	96	48	-	16	13	-	-
DIPTERA									
Chironomus (Cryptochironomus)		-	-	16	-	4	8	-	-
C. (Dicrotendipes)		-	-	-	-	-	-	-	Q
C. (Endochironomus)		-	Q	-	-	-	-	Q	-
Cricotopus		-	-	-	-	-	-	-	-
Glyptotendipes		-	Q	-	-	-	-	-	-
Gnoldichironomus holoprasinus		-	Q	-	-	-	-	-	-
Harnischia		-	Q	-	-	-	-	-	-
Palpomyia tibialis		-	-	-	-	-	2	-	-
Polypedilum		80	-	-	-	28	-	-	-
Probezzia		-	-	-	-	-	-	-	-
Procladius		-	-	272	-	36	-	-	Q
Pseudochironomus		-	-	-	-	-	-	-	-
Simulium		-	-	-	-	-	-	-	Q
Tanypus		160	-	-	-	-	-	-	-
Tanytarsus		-	-	-	-	-	-	-	-
GASTROPODA									
Aplexa		-	-	-	-	-	-	-	-
Physella		-	32	-	-	-	-	-	-
Gyraulus		-	544	-	-	-	-	Q	-
Helisoma		-	16	16	-	-	-	-	-
Lymnaea		-	-	-	-	-	-	-	-
Promenetus		-	16	-	-	-	-	-	-
Pseudosuccinea		-	-	-	-	-	-	-	-
HEMIPTERA									
Corixidae		-	Q	-	-	-	Q	Q	-
ODONATA									
Argia		-	-	-	-	-	-	Q	-
Gomphus		-	-	-	-	-	-	Q	-
PELYCYPODA									
Musculium		-	-	-	-	-	-	-	Q
Pisidium		-	-	64	-	-	-	-	-
Sphaerium		-	-	-	-	4	-	-	-
SUBTOTAL		280	710	416	0	88	24	7	4
SUBTOTAL KINDS		3	11	5	0	5	4	7	4
TOLERANT ORGANISMS									
DIPTERA									
Chironomus		40	624	192	2	-	8	-	Q
C. (Einfeldia)		-	32	-	-	-	-	-	-
C. (Kiefferulus)		-	Q	-	-	-	-	-	-
Culicidae		-	-	-	-	-	-	-	-
GASTROPODA									
Physa		-	32	48	-	-	-	-	-
HIRUDINEA		-	-	-	-	-	-	Q	-
OLIGOCHAETA									
Lumbriculidae		-	-	-	-	-	-	-	-
Naididae		-	-	-	-	-	-	-	-
Tubificidae		80	-	32	5	144	6	Q	-
SUBTOTAL		120	656	272	7	144	14	2	1
SUBTOTAL KINDS		2	4	3	2	1	2	2	1
GRAND TOTAL/SQ. FT.		400	1615	688	7	240	38	12	6
NUMBER OF KINDS		5	16	8	2	7	6	12	6

Q=Organism not collected quantitatively, arbitrarily given value of one for computing
NS=Not sampled

control structure provides aeration of streamflow entering this reach.

C. PHYTOPLANKTON

Phytoplankton (suspended algae) were collected from a total of 16 stations on the Souris River and 5 stations on the Des Lacs River during both the June and October surveys. Phytoplankton data for both rivers for the June survey are presented in Table VII-5 and for the October survey in Table VII-6. Predominant phytoplankton genera are listed in Table VII-7.

Souris River

During June, the phytoplankton collected were primarily coccoid green forms with Scenedesmus the predominant genus. Total algal counts were low in the upper 130 miles of the river (RM-358.2 to RM-222.1), ranging from 792 to 5,442 per milliliter (ml). Algal cell volumes were also low, ranging from 1.1 to 12.2 parts per million (ppm). This reach of the river includes Lake Darling and the Upper Souris National Refuge.

Both algal counts and volumes sharply increased in the 100-mile reach downstream from Minot (RM-185.6 to RM-98.7). Algal counts ranged from 14,586 to 29,568 per ml and algal volumes ranged from 21.4 to 28.8 ppm. This reach of the river received nutrients from a number of sources including urban runoff from the Minot area, rural runoff from the communities of Valva and Towner.

In the lower 75 miles of the river, located in the J. Clark Salyer Wildlife Refuge, algal counts and volumes were similar to those observed in the river upstream from Minot.

A significantly different pattern of algal growths was observed during the October survey although Scendesmus was still the predominant genus. Except at RM-185.6 (Sta. 5-13) downstream from Minot, both algal counts and volumes were low in the entire free flowing portion of the river. At the one station with higher algal numbers, total algal counts (7,524 per ml) were less than one-third of June levels and the algal volume was only 60 percent of the June volume. Algal counts at other stream stations showed even greater reductions below June levels.

Whereas both algal counts and volumes were low in the impoundments in June, a number of the impoundment stations exhibited high algal volumes in October. The highest algal volumes were obtained from Lake Darling at RM-305.8 and RM-278.4 (Stas. LD-1 and LD-3). Algal volumes of 191.0 and 66.5 ppm at the two lake stations were primarily composed of the blue-green algae Aphanizomenon flos-aquae.

The highest algal counts were found in the refuge impoundments in the lower 10 miles of the river. These high counts were predominantly Scenedesmus.

Des Lacs River

Phytoplankton collections from the Des Lacs River in June contained low algal volumes and counts.

TABLE VII-5

PHYTOPLANKTON DATA
JUNE 1969

Station	River Mile	Kind of Algae (Phytoplankton per Milliliter)					Predominate Genera	Total Volume (ppm)	Total No/ml
		Blue Greens	Greens	Flagel-lates	Centric Diatom	Pennate Diatom			
				Souris River					
USC-1	358.2	0	1,122	165	33	132	Scenedesmus	1.4	1,452
US-1	353.5	0	792	297	99	99	Scenedesmus	1.9	1,287
US-3a	326.7	0	1,518	1,386	264	66	Trachelomonas	12.2	3,234
LD-1	305.8	462	1,650	132	132	132	Ankistrodesmus	9.5	2,508
LD-3	278.4	132	242	110	330	0	Melosira	1.2	792
S-4	243.5	0	594	165	132	165	Ankistrodesmus	1.1	1,056
S-6	228.9	264	1,584	132	198	726	Ankistrodesmus	4.4	2,904
S-9	222.1	594	2,310	660	660	1,188	Ankistrodesmus	8.6	5,442
S-13	185.6	66	6,270	264	398	0	Scenedesmus	27.6	27,984
S-15	161.0	0	6,600	264	462	66	Scenedesmus	28.8	29,568
S-18	101.9	66	15,972	1,188	396	792	Scenedesmus	26.0	18,606
S-20	98.7	132	12,078	462	462	1,386	Scenedesmus	21.4	14,586
S-23	73.4	66	5,478	715	330	462	Scenedesmus	6.1	7,062
S-35	16.7	99	1,782	231	264	363	Crucigenica	2.7	2,740
S-37	7.9	132	3,762	198	66	264	Ankistrodesmus	2.4	4,422
S-41c	0.0	0	858	198	132	33	Phytoconis	0.6	1,221
				Des Lacs River					
DL-3	243.7 + 36.2	0	0	88	22	110	Navicula	0.1	220
DL-4	243.7 + 35.0	880	198	44	0	66	Aphanizomeon	2.3	1,188
DL-5	243.7 + 34.0	462	88	176	44	88	Aphanizomenon	1.0	858
DL-9	243.7 + 29.5	0	220	220	198	374	Navicula	0.4	1,012
DL-17	243.7 + 1.5	0	198	66	44	572	Navicula	0.6	572

TABLE VII-6

PHYTOPLANKTON DATA
OCTOBER 1969

Station	River Mile	Kind of Algae (Phytoplankton per Milliliter)					Predominate Genera	Total Volume (ppm)	Total No/ml
		Blue Greens	Greens	Flagel-lates	Centric Diatom	Pennate Diatom			
				Souris River					
USC-1	358.2	0	1,353	891	33	330	Scenedesmus	1.4	2,607
US-1	353.5	0	594	374	110	66	Chlamydomonas	1.0	1,024
US-3a	326.7	0	2,508	1,848	396	0	Scenedesmus	7.8	4,752
LD-1	305.8	8,052	198	132	594	198	Aphanizomenon	191.0	9,174
LD-3	278.4	7,128	396	132	396	132	Aphanizomenon	66.5	8,182
S-4	243.5	0	1,782	330	429	165	Ankistrodesmus	2.0	2,706
S-6	228.9	0	2,838	330	396	132	Ankistrodesmus	2.0	3,696
S-9	222.1	0	3,498	1,188	264	330	Scenedesmus	7.5	5,280
S-13	185.6	0	4,686	462	1,716	660	Scenedesmus	16.8	7,524
S-15	161.0	99	2,178	792	297	198	Oocystis	7.5	3,564
S-18	101.9	0	2,234	924	198	330	Scenedesmus	7.1	3,686
S-20	98.7	0	2,508	1,436	330	264	Scenedesmus	5.3	4,538
S-23	73.4	33	1,782	594	66	165	Oocystis	5.0	2,640
S-35	16.7	198	8,978	1,254	726	396	Scenedesmus	9.3	11,552
S-37	7.9	264	15,840	3,432	792	528	Scenedesmus	29.2	20,856
S-41c	0.0	660	38,280	7,260	5,940	1,980	Scenedesmus	60.7	54,120
				Des Lacs River					
DL-3	243.7 + 36.2	99	924	363	231	693	Ankistrodesmus	4.6	2,310
DL-4	243.7 + 35.0	220	1,540	440	13,200	0	Melosira	20.0	15,400
DL-5	243.7 + 34.0	462	924	264	17,754	66	Melosira	19.7	19,526
DL-9	243.7 + 29.5	33	1,584	429	363	627	Ankistrodesmus	6.0	3,036
DL-17	243.7 + 1.5	0	2,904	792	990	396	Ankistrodesmus	5.2	5,082

TABLE VII-7

PREDOMINANT PHYTOPLANKTON GENERA

Blue-Green Algae (Myxophyceae)

- Agmenellum
- Anabaena
- Aphanizomenon
- Comphosphaeria
- Oscillatoria

Green Algae (Chlorophyceae)

- Actinastrum
- Ankistrodesmus
- Closterium
- Coelastrum
- Cosmarium
- Crucigenia
- Dimorphococcus
- Golenkinia
- Lagerheimia
- Oocystis
- Pediastrum
- Phytoconis
- Scenedesmus
- Staurastrum
- Tetraedron
- Tetrastrum

Diatoms (Bacillariophyceae)

- Asterionella
- Cocconeis
- Cyclotella
- Cymatopleura
- Cymbella
- Diatoma
- Fragilaria
- Gomphonema
- Gyrosigma
- Melosira
- Navicula
- Nitzschia
- Pinnularia
- Pleurosigma
- Stephanodiscus
- Surirella
- Synedra

Flagellates (Chrysophyceae, Euglenophyceae, and Chlorophyceae)

- Carteria
- Chlamydomonas
- Dinobryon
- Euglena
- Phacus
- Trachelomonas

The diatom Navicula was the predominant genus except in Middle Des Lacs Lake (Stations DL-4 and DL-5) where the blue-green alga Aphanizomenon flos-aquae was predominant. Middle Des Lacs Lake receives the untreated waste discharge from Kenmare.

Phytoplankton concentrations during the October survey were significantly higher and consisted primarily of the coccoid green alga Ankistrodesmus at all stations except the two Middle Des Lacs Lake stations where the diatom Melosira was dominant. Algal volumes were about 20 ppm in the lake.

Intense blooms of blue-green algae have occurred in the Des Lacs River drainage in the past and have contributed to livestock deaths, taste and odors, and other nuisance conditions [6]. Growths of these algae never attained nuisance proportions during either survey. The abnormal rainfall and high streamflow conditions throughout the summer months could have suppressed the growth and development of algae and prevented severe nuisance conditions.

D. SEDIMENTS

Bottom sediments are composed of materials that have settled out of overlying waters or that have been moved along the bottom by stream currents. The composition of bottom sediments in most cases thus reflects a history of water quality conditions in overlying and upstream waters. Also, bottom sediments can affect water quality in overlying waters by exerting high oxygen demands, by releasing toxic gases such as hydrogen sulfide, and by recirculating nutrients when disturbed by currents or wave action. Examination of the composition of bottom sediments is thus useful in evaluating past and present water quality conditions and predicting future conditions.

Recently, water quality investigators have utilized the nutrient composition of bottom sediments as a water quality index. Finger and Wastler [7] presented organic carbon-organic nitrogen ratios as an index of pollution in Charleston Harbor, South Carolina. Mackenthun, et al.[8] have reported nutrient ratios in sediments from a eutrophic lake in Maine. Ballinger and McKee [5] have developed an Organic Sediment Index (OSI), the product of the percent organic carbon and the percent organic nitrogen in sediments, to divide sediment samples into four types of conditions. Organic Sediment Indices and sediment materials corresponding to the four types of conditions are shown in Table VII-8.

Sediment samples were obtained from 26 stations on the Souris River during both the June and October survey. These samples were analyzed for organic carbon (C), organic nitrogen (N) and phosphorus (P). Results of the analyses are presented in Table VII-9. Organic Sludge Indices computed from the data of Table VII-9 are presented in Table VII-10.

Dry weight organic carbon in the Souris River sediments ranged from 0.70 to 9.5 percent and dry weight organic nitrogen ranged from 0.05 to 0.90 percent. The OSI values ranged from 0.035 to 3.50. Dry weight phosphorus in the sediments ranged from 0.026 to 0.18 percent. The sediments could be classified as predominately of Types II and III which are characterized by large amounts of organic

TABLE VII-8

ORGANIC SEDIMENT INDEX FOR TYPICAL BOTTOM SEDIMENTS

OSI	Sediment Type	Sediment Materials
0-0.5	I	Sand, Clay, Old Stable Sludge
0.5-1.0	II	Organic Detritus, Peat, Partially Stabilized Sludge
1-5	III	Sewage Sludge, Decaying Vegetation, Pulp and Paper Waste, Sugar Beet Wastes
5-10	IV	Actively Decomposing Sludge, Fresh Sewage, Matted Algae, Packinghouse Wastes

detritus and vegetative material.

With the exception of the Lake Darling stations, bottom samples obtained from the upper 250 miles of the Souris River (RM-101.9 to RM-358.2) reflected relatively stable sediment conditions with OSI values ranging from 0.035 to 1.41. The phosphorus content (0.026 to 0.18 percent) was much higher in relation to carbon and nitrogen contents, however, than would be expected for stable sediments. This condition persisted throughout the study area. Sediments obtained from Lake Darling had slightly higher OSI values (ranging from 0.95 to 2.60) than observed in the remainder of the upper river. Such an increase would be anticipated because of greater deposition of organic detritus in the impoundment.

At RM-101.5 (Sta. 5-19) 100 yards downstream from the Towner sewage outfall, sediment samples had high OSI values (2.80 to 4.70) indicative of sewage sludge undergoing decomposition. At RM-98.7 (Sta. 5-20), approximately three miles below the outfall, observed OSI values (1.12 to 3.20) were still indicative of organic wastes undergoing stabilization. At RM-73.4 and 52.3 (Stas. 5-23 and 5-25), the OSI values ranged from 0.091 to 0.70 indicating that almost complete stabilization of sediments had been achieved.

Sediment samples collected in the reach from RM-48.6 to RM-1.0 (Stas. 5-27 to 5-40), located in the J. Clark Salyer Wildlife Refuge, exhibited OSI values ranging from 0.68 to 6.5 which were indicative of an abundance of organic detritus, presumably decaying vegetation in the shallow impoundments. This section of the river, which is devoted entirely to wildlife uses, would appear to be serving as a collection and stabilization area for decaying organic material.

Sediment samples obtained near the International Border (Sta. 5-41c) downstream from the refuge had low OSI values which would seem to indicate that little organic material from the refuge is transported downstream.

TABLE VII-9

ORGANIC CARBON, NITROGEN, AND PHOSPHORUS IN SEDIMENTS

Station	River Mile	June 1969			October 1969		
		Carbon	Nitrogen	Phosphorus	Carbon	Nitrogen	Phosphorus
		(Percent Dry Weight)					
USC-1	358.2	2.1	.13	.034	1.6	.09	.026
US-1	353.5	2.5	.20	.053	1.9	.15	.053
US-4	320.5	2.8	.29	.084	3.9	.37	.092
LD-1	305.8	3.1	.39	.090	4.2	.39	.086
LD-2	295.6	4.0	.49	.095	0.9	.11	.046
LD-3	278.4	3.9	.44	.120	5.2	.50	.095
S-1	275.3	1.1	.22	.036	2.6	.25	.079
S-3	267.4	2.2	.18	.094	4.0	.08	.083
S-4	243.5	2.8	.24	.072	1.5	.12	.072
S-6	228.9	6.7	.21	.090	3.2	.22	.098
S-9	222.1	3.3	.08	.085	2.7	.19	.110
S-11	197.6	0.9	.09	.050	0.7	.07	.037
S-13	185.6	0.7	.05	.047	0.8	.06	.048
S-15	161.0	3.4	.29	.180	2.4	.21	.098
S-18	101.9	3.8	.34	.120	0.7	.16	.072
S-19	101.5	6.8	.69	.120	4.0	.69	.130
S-20	98.7	4.7	.68	.170	3.4	.17	.046
S-23	73.4	3.2	.22	.100	2.4	.27	.093
S-25	52.3	0.9	.10	.049	1.5	.18	.050
S-27	48.6	3.2	.38	.071	5.0	.58	.072
S-28	42.4	7.2	.90	.093	6.0	.71	.073
S-33	32.1	2.6	.26	.067	5.0	.49	.078
S-35	16.7	7.0	.62	.071	4.4	.44	.075
S-37	7.9	2.4	.33	.067	6.0	.39	.066
S-40	1.0	3.3	.48	.110	4.0	.35	.070
S-41c	0.0	2.7	.19	.080	1.9	.13e	.058

TABLE VII-10

SOURIS RIVER ORGANIC SEDIMENT INDICES

Station	River Mile	June OSI	October OSI
USC-1	358.2	.27	.14
US-1	353.5	.50	.30
US-4	320.5	.81	1.40
LD-1	305.8	1.21	1.64
LD-2	295.6	2.00	.95
LD-3	278.4	1.71	2.60
S-1	275.3	.24	.65
S-3	267.4	.40	.32
S-4	243.5	.70	.18
S-6	228.9	1.41	.70
S-9	222.1	.26	.51
S-11	197.6	.08	.05
S-13	185.6	.04	.05
S-15	161.0	.99	.50
S-18	101.9	1.30	.11
S-19	101.5	4.70	2.80
S-20	98.7	3.20	1.12
S-23	73.4	.70	.65
S-25	52.3	.09	.27
S-27	48.6	1.22	2.90
S-28	42.4	6.50	4.30
S-33	32.1	.68	2.45
S-35	16.7	4.34	2.04
S-37	7.9	.80	2.34
S-40	1.0	1.60	1.40
S-41c	0.0	.51	.25

APPENDIX A

STATE OF NORTH DAKOTA
WATER QUALITY AND PURITY STANDARDS FOR
THE SOURIS RIVER AND THE DES LACS RIVER*

The standards of quality as hereinafter set forth are hereby adopted and established for the Souris River from where it enters the State at the North Dakota-Canadian border to its point of departure at the North Dakota-Canadian border near Westhope; the Des Lacs River from its point of entry into North Dakota at the Canadian border to its confluence with the Souris River.

The general policy, definition of terms used, general requirements and general conditions applicable to all surfaced waters in the State of North Dakota are a part of these standards.

These standards may be amended, or additions added, if justified by future developments that are consistent with the preservation or enhancement of the quality of these waters.

I. WATER USAGE

The quality of water in the streams shall be maintained in accordance with these standards which have been promulgated for the following best intended uses of these waters: (1) Municipal water supplies, (2) Industrial water supplies, including food processing, (3) Recreation, fishing and wildlife, and (4) Agricultural uses. These uses, as listed, are not meant to indicate any priority of use, nor are they considered exclusive, nor is it the intention to prohibit other beneficial uses if they do not interfere with the water quality in the stream as designated by these standards.

A. The quality of waters shall be such that after treatment consisting of coagulation, settling, filtration, and chlorination, or equivalent treatment processes, the treated water shall meet the bacteriological, physical, and chemical requirements of the latest edition of the United States Public Health Service Drinking Water Standards and any revision or amendments thereto.

B. The quality of water shall permit their uses for industrial purposes, including food processing, with such treatment as may be necessary to prevent scaling, corrosion, or other unsatisfactory conditions, or as may be required by the processed materials.

C. The quality of water shall permit the propagation and life of fish species native in the vicinity under natural conditions and shall be suitable for boating and other water recreation.(1) Low flows or natural conditions in the river may at times limit the value of the waters for fishing. There shall be no inhibition or injurious effects to wildlife using the waters.

D. The quality of the water shall permit its use for agricultural irrigation without

* Approved May 22, 1970 by Secretary of Interior.

adverse effects or significant damage to any crops or vegetation normally grown in the area. It will be suitable for stock watering.

II. SPECIFIC STANDARDS

These standards shall be met at all times, regardless of flow, unless an exception is granted by the State Water Pollution Control Agency and the United States Department of the Interior for all interstate waters and the State Water Pollution Control Agency for intrastate waters.

A. No municipal, industrial, or other waste discharges, after resonable (2) opportunity to mix and dilute with the receiving waters, shall cause the following minimum conditions or concentrations to be exceeded in the waters:

1. Dissolved Oxygen	Not less than 5 mg/liter at any time in the Lake Darling Reservoir. Not less than 5 mg/l for any 16 hours of the day nor any measured readings less than 4 mg/l at any one time in the stream.
2. Temperature	(a) Not to exceed 90°F. (b) The maximum increase shall not be greater than 5°F above natural background conditions. Natural background conditions are those that exist before the addition of any controllable heat source.
3. pH	Minimum 7.0. Maximum 9.0.
4. Coliform Organisms	The average arithmetical monthly (MPN) shall not exceed 1,000/100 ml. in the Lake Darling Reservoir. The average arithmetical monthly (MPN) shall not exceed 3,000/100 ml. in the stream or in an MPN exceeding this number in more than 20% of the samples collected during any one month, or in an MPN exceeding 7,500 in more than 5% of such samples per month.
5. Sodium	60% of total cations as milliequivalents per liter.
6. Radioactive Materials	No discharge permitted unless the materials are readily soluble or dispensable in water and of acceptable quantities as recognized by the State Health Department and other appropriate State or Federal agencies.
7. Unspecified Substances	None in concentrations or combinations that interfere with the intended water use. This shall

include specific chemicals or substances that may prove harmful or injurious to humans, animals, or aquatic life, or to local grown crops which may be irrigated by these waters.

The discharge of treated sewage, industrial wastes, or other wastes to surface waters not specifically mentioned but which are tributary to these waters, shall not, by reason of such discharges, cause the standards for these waters to be exceeded.

It shall be the responsibility of all communities, industries, or others owning or responsible for operating treatment facilities, to operate such plants continuously and at their maximum efficiency.

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1. In general, waters with a coliform count of 1,000/100 ml. or less are considered relatively safe for swimming. Natural physical characteristics of the river banks and bed and natural water turbidities in the area must also be considered.

2. The distance of river flow to allow for a reasonable opportunity to mix and dilute wastes shall be at the discretion of the State Department of Health and will be based upon stream flow conditions at the time of sampling, except where such discharges may adversely affect a beneficial water use immediately downstream or in close proximity to the waste discharge point. In such instances, a change in the method of waste discharge or other control measures may be required.

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